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Keeping Engineers Informed

By R. T. CASEY. (From *Machine Design, U.S.A.*, Vol. 26, No. 6, June 1954, pp. 119-122, 3 illustrations.)

LARGE quantities of periodical technical literature are available to the engineer. They cover every aspect of his job and their quality is, in general, excellent. The extent and efficiency of the utilisation of this valuable material by the engineer, on the other hand, are often deplorably low.

Technical magazines, journals, and periodicals provide the most practical way for the engineer to keep himself up-to-date on the three most important aspects of his job, which are :—(1) Current technical advances, (2) new products, materials, and services available for use on his job, and (3) products and activities of other manufacturers.

Before, however, the engineer can come into contact with this useful information, several things are necessary. He must know the names of the magazines which are related to his work ; he must regularly secure copies of these magazines ; and, if the information is to be truly useful to him, he must have readily available means of access to the vast storehouse of data and information held in the pages of prior issues of such publications.

Several approaches to the problem are possible. Almost any of these approaches, if seriously undertaken and applied with common sense, will produce results. For purposes of illustration, this article discusses a service organised, instituted, and carried on for a period of several years for the engineers in a medium-sized electrical manufacturing plant.

Before the institution of this service, the individual engineers at the plant were receiving magazine copies in a more or less haphazard fashion. No one could say with any assurance what currently published magazines were most pertinent to the work of the engineers, or which of these magazines, if any, were being received. Often, changes in magazine addressing had not kept up with changes in personnel location, and indexing and filing facilities were completely absent.

The first step taken to remedy this situation was a survey to assemble data. Each engineer was asked to list the magazines he was then receiving or reading regularly. He was also asked if there were any other magazines he would like to receive. From information gained from this survey, a master list of magazines was compiled. This list was expanded further by adding the names of other magazines gleaned from other sources. The list was then found to consist of some 45 magazines.

At this point, and after discussion with other members of engineering management and with the engineers themselves, it was decided that the objective of efficient utilisation of technical publications could best be achieved by the institution of a magazine " circulation service." According to this plan, the magazines would be received by one person, who would circulate them to the engineers interested. This system has been found to have many advantages not obtainable when subscriptions are placed in the names of individual engineers, and magazines are received directly by them.

Upon review of the master list, it was obvious that many of the magazines should not be considered further. Magazines which were clearly not pertinent were crossed off the list. A magazine on architecture, for example, was not considered to have enough direct relation to the company's work to justify routing it regularly to engineers' desks. Magazines of the type which report on economic conditions and business statistics were also not considered for general circulation. Two publications were found to cover substantially the same material, and in this case only one was retained for further handling by the service.

This preliminary weeding-out process produced a much smaller " working " list of about 25 magazines. The next step was to determine the interest of the engineers in these magazines. Accordingly, the list of magazines was circulated, together with the request that each engineer should indicate which magazines he would like to receive regularly. A copy of each magazine was made available for his inspection. No limit was set on the number of magazines each engineer could ask for.

The results of this survey were then studied, and a list was compiled of magazines which would be obtained and circulated. In general, it was felt that interest should be shown by at least three engineers in order to justify handling of the magazine by the circulation service. On the other hand, in several cases, two or three copies of a single magazine were ordered. It was felt that, for proper use by the engineers, no single copy should regularly be routed to more than six engineers. The number of magazines to be handled was then found to be reduced to 15, and on this basis the circulation service began operation.

While any one of a number of schemes can be used for a routing slip, the following has proved satisfactory:—

A separate routing slip is made for each magazine. For a monthly magazine, 12 copies of the slip are prepared for each copy. For instance, if there are 15 readers who wish to see a particular magazine, three copies are ordered, three routing slips are made up, with five names on each, and 12 copies of each routing slip are prepared. Each set of 12 slips is then marked with the corresponding month of the year.

Thus, when a magazine is received in the mail each month, the corresponding routing slip is affixed to the cover. Since the routing slips are marked with months in advance, it is always possible to tell whether a given month's issue, or even a given copy, has been received.

The routing slip also provides space at the right of each name for marking pages likely to be of interest. Extra spaces are provided at the bottom for writing in the name of anyone not on the regular list to whom the magazine should also be directed.

An incidental observation in this connection is that the routing slip should not cover the entire front of the magazine. Furthermore, unless it is very small, it should not be taped, stapled, or stuck at all four corners. Many magazine covers carry pictures or titles of important articles, all of which are meant to be seen and read. By attaching the routing slip at one side or at the top only, it can be lifted up, so that the whole cover can be seen.

A constant problem with an undertaking such as this is to keep magazines moving. One help is to keep routing slips as short as possible—not more than six names each. Another aid is provided by a note at the

bottom of the slip to the effect that circulation should not be held up and that, if the recipient is unable at the moment to read the publication, he should cross off his name from the list and re-enter it at the bottom for later return of the publication.

Most engineers will be co-operative with this kind of arrangement. For the few who are not, a further precaution is taken. All routing slips are made to terminate with the supervisor of circulation. Since he also keeps back issues of magazines, he will notice when more than one or two months pass before the return of a specific issue. He will then send a note around to " flush out " the copy. All such copies should complete circulation within two months.

Copies which are filed should be so marked. In connection with the filing of magazines, a convenient filing device for magazines, especially the thinner types, is provided by open-back cut-away boxes. These containers protect copies from becoming dog-eared, yet permit easy access and viewing of the major portion of the backs of the magazines. In addition, the boxes keep the copies from sagging and from packing together too tightly on the shelf.

Efficient use of magazines requires that at least some back copies be kept on file. Where a complete technical library is not available and where storage facilities are limited, back copies should be kept of at least the most important magazines, and at least one year of back issues should be kept.

A useful index of material in selected technical periodicals can be built up by utilising magazine-contents pages. For instance, when the limit of storage facilities is reached and it becomes necessary to begin discarding copies, the contents pages are removed from the magazines before they are discarded. These are kept in a separate binder, providing a comprehensive index to the material in many back issues. A copy of any technical magazine can almost always be obtained from a public general or technical library, once the desired issue is identified.

The circulation service can supplement its function of supervising magazine circulation by helping to make technical papers, reports, and books available to engineers. Technical papers can be routed to those engineers most likely to be interested in their subject matter. Periodical indices and listings of technical material from various sources, as well as periodical reports of a more technical nature, are perhaps better handled by the service on a library check-out basis. If space cannot be assigned for use as a reading room or area, a display rack can be provided in a spot where all engineers will see if often.

Where facilities permit, a master data-file or index of all technical material in magazines and technical papers, reports, etc., of interest will also be of very great value.

Whatever system is now in use, another look at how periodical technical literature is being handled may prove worthwhile. Efficient use of such material requires investment of only a little time and effort, combined with common sense. The returns can be very considerable indeed.

RUSSIA

The Use of Steam-Gas Cycles in Combined District-Heating and Power Stations

By A. E. GELTMAN and G. B. LEVENTHAL. (From *Vestnik Mashinostroyeniya*, Vol. 34, No. 1, January 1954, pp. 19-23, 6 illustrations.)

In Russia, thermal power stations with back-pressure turbines, supplying district heating in addition to electrical power, are as common as condensing power stations. To avoid confusion, the phrase " combined heating and power station " is used to denote the class of plant which is the subject of this article. The author claims that, as a result of extensive analytical investigations not published in the original article, the introduction of a boiler roughly of the " Velox " type (in which the combustion space is highly supercharged by means of exhaust-gas turbine-driven air and gas superchargers) can provide considerable economy if the exhaust from the gas turbine is also used for the heating of water.

IN the conventional steam power station, air and the products of combustion merely serve as a heating agent in the boiler. From the point of view of the second law of thermodynamics, such a utilisation of the heat of flue gas is imperfect, inasmuch as a substantial proportion of the heat in the gas is used at relatively low temperatures for feed-water heating and for the evaporation of water in the boiler. The regenerative feed-water heating by steam extracted from the turbine overcomes this drawback only in part. The specific yield of energy of the internal (regenerative) heat extraction, measured in kWh/kcal, falls sharply with an increase in the pressure of the extracted steam. As a result, the effectiveness of regenerative feed-water heating in the range of high feed-water temperatures is substantially reduced.

In Fig. 1, specific energy yield is plotted for a condensing power station with initial steam conditions of 90 atm abs and 500° C against the enthalpy (temperature) of feed water. Curves I apply to an infinite number of stages of regenerative feed-water heating. The broken line represents the case where reheated condensate of the extracted steam could not be utilised for the generation of additional energy. Curve II applies to a power station with five stages of regenerative feed-water heating. When the number of stages is limited, the optimum temperature of regenerative feed-water heating, i.e., 215° C at 90 atm abs, is considerably below the saturated steam temperature (302° C).

Though a substantial increase in the effectiveness of regenerative feed-water heating in the region of high feed-water temperatures cannot be achieved in a steam cycle, it can be achieved by means of a gas cycle, since

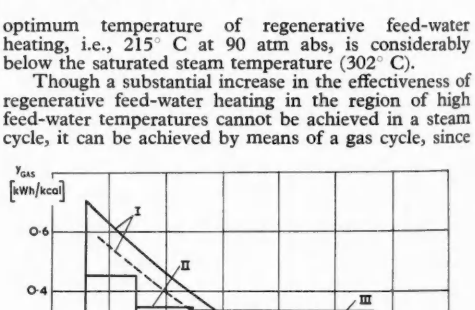
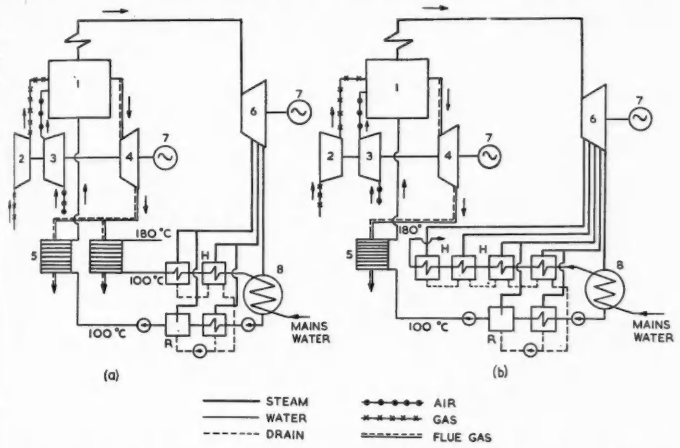


Fig. 1. **Specific yield of electrical energy from heat transferred to feed water for pure steam regenerative cycles and for combined steam and gas cycle.**

this is characterised by higher temperatures of heat supply, and hence the steam-gas compound installation becomes necessary. This considerably increases the internal heat consumption insofar as feed-water heating can be continued to a temperature of about 280° C, on account of the heat in the exhaust gas ; with a higher excess-air coefficient, a certain degree of steam generation can even be achieved in the economiser.

In Fig. 1 the horizontal straight line III corresponds to the value y_{gas} of specific energy yield with the following initial data :—The fuel is a gas with the low calorific value of 900 kcal/m³. The temperature of the gas at the gas-turbine inlet is 700° C. The temperature of the air at the compressor inlet is 20° C, and the inlet



(1) High-pressure steam generator.
(2) Gas compressor.
(3) Air compressor.
(4) Gas turbine.
(5) Economiser.
(6) Steam turbine.
(7) Alternator.
(8) Condenser.
(H) Mains-water heaters.
(R) Regenerative feed-water heaters.

Fig. 2. **Schematic layouts of steam-gas combined heating and power stations for a single-pipe system of district heat supply.**

temperature of the fuel gas is 30° C. Compressor pressure ratio is 6·4. Internal adiabatic turbine efficiency, 0·87 ; air-compressor efficiency, 0·87 ; gas-compressor efficiency, 0·78. Excess-air coefficient, 1·15. Gas outlet temperature, 150° C. These conditions result in a specific energy yield of 0·337 kWh/kcal.

It can be seen from Fig. 1 that, in the actual installation, the specific energy yield (Curve II) exceeds the yield with regenerative heating beyond a feed-water enthalpy of 122 kcal/kg. The increase in power output in a gas-steam installation, compared with that of a pure steam installation, is indicated in Fig. 1 by the shaded area. It may be remarked that the optimum feed-water enthalpy at the inlet to the economiser would be below the above value, because the drop in feed-water temperature permits a reduction in the heat loss of the outlet gas (not taken into account in Fig. 1).

The value y_{gas} changes only marginally with an increase in the coefficient α of excess air. However, this increase substantially raises the internal heat consumption. Thus, for example, with $\alpha = 1{\cdot}9$ and $t = 100°$ C, the water in the economiser is heated almost to the saturation temperature, and at higher values of α, steam is generated in the economiser.

In a steam-gas installation, the pressure in the combustion space and in the gas passages of the boiler must be raised, in order to expand in the gas turbine. This permits a higher rate of combustion and greater heat transfer. The permissible rates of combustion are approximately proportional to the pressure and hence the volume of the combustion chamber is substantially reduced. The increase in heat transfer by convection, with a higher pressure on the gas side, is due to higher gas density, leading to a lower pressure drop and hence to lower power consumption. Thus, in a steam-gas installation, with a working pressure of 6 atm abs, the mass flow velocities of gas can be increased about 6·4 times and the convective heat-transfer surfaces can be reduced about 4·4 times. This economy in materials and building space is of particular value in combined heating and power stations.

In order to choose the optimum conditions for the development of remote heating schemes, it is useful to consider a single-pipe system of heat supply with multi-stage heating of district heating water. Such a system represents the most general case, which embraces simpler schemes, and it is necessary to select the optimum steps and temperatures for regenerative feed-water heating and district heating by the waste heat of exhaust gas and steam extracted from the turbines.

Fig. 2a shows a diagram of a gas-steam combined heating and power station, in which feed water and mains water are heated to a definite temperature by the steam extracted from turbines, and subsequently heated by exhaust gas in economisers. Fig. 2b is a diagram showing heating of mains water by steam only, the use of exhaust gas being confined to the heating of feed water.

Fig. 3 shows specific power yield as a function of the enthalpy (temperature) of feed water. The ordinate is a measure of the specific energy yield y_F due to feed-water heating and y_M due to the preheating of mains water.

The specific yield of energy is defined as the ratio of a small increment of power generated to the increment of heat, when the preheating temperature increases by Δt. Thus, the specific yields referred to mains-water and feed-water preheating are :

$$y_M = \Delta E_M / \Delta Q_M$$
$$y_F = \Delta E_F / \Delta Q_F$$

When the power station is operated in accordance with the heating programme, the heat spent on regenerative feed-water heating is related to the heat spent on the heating of mains water for a given temperature interval Δt, by the following expression :

$$\Delta Q_F / \Delta Q_M = G_F / G_M,$$

where Q_F is the feed-water throughput and Q_M is the mains-water throughput.

Consequently, μy_F (Fig. 3) represents the specific energy yield in feed-water heating, referred to a unit of heat supplied to the outside consumer. Based on an analysis of a variety of schemes for average conditions, the value of μ is assumed to be 0·3. Curves I and I' illustrate the specific yield of energy for the pure-steam cycle with an infinite number of feed-heating stages.

Curves II and II′ give the yield for a gas-steam installation. The temperature of exhaust gas is 140° C ; the temperature of feed water and mains water at the entry into the economiser is 100° C ; the excess-air coefficients vary between 1·15 and 3·6 ; the remaining data are the same as those for Fig. 1. The heating of mains water up to 180° C corresponds to conditions of district-heating supply requirements. The preheating of feed water in the economiser is carried out in accordance with the needs of the thermal balance, depending on the excess-air coefficient α.

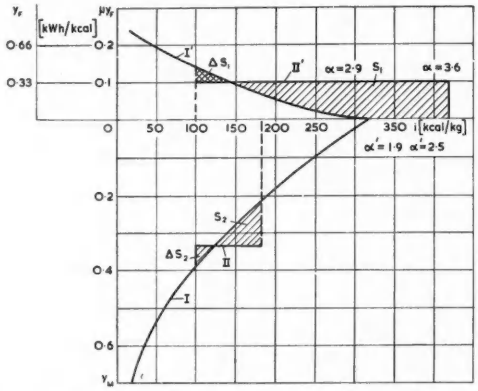


Fig. 3. **Specific yield of electrical energy from heat transferred to mains water and feed water, both referred to a unit of heat supply.**

The values of enthalpy of feed water at the economiser outlet, corresponding to different values of α, are shown in Fig. 3 (Curve II′). Here, α' denotes the values of α which correspond to the case of preheating by exhaust gas of feed water only, whilst α denotes parallel preheating by gas of feed water and mains water. On account of combining the gas and steam cycles, the increase in the specific energy yield of internal heating is expressed by the difference between the areas S_1 and ΔS_1, and in the specific energy yield of external heat consumption by the difference between S_2 and ΔS_2.

A comparison of the areas indicated shows that, in spite of a considerably larger flow of mains water compared with that of feed water, the utilisation of exhaust heat for the preheating of mains water does not yield substantial results, owing to the limited final preheating temperature, which cannot exceed 180° C and thus precludes the relatively effective stages of extracted steam. On the other hand, gas preheating of feed water is advantageous, because it permits effective utilisation of the internal heat consumption in the region of high temperatures and does not rely on ineffective extraction of steam at high pressure.

The question of the effectiveness of raising the air-excess coefficient cannot be decided on the basis of the specific yield of energy of heat consumption, because this does not measure the variation in heat losses in the exhaust gas. For this reason, the evaluation of the excess-air coefficient is more appropriately performed on the basis of more general considerations, i.e., the total thermal efficiency ensured by the particular combined heating and power scheme, compared with the combined thermal efficiency of a separate condensing power station and a boiler for district-heat supply.

The heat saving can be determined from the formula

$$\Delta Q = \Sigma Y\,(q_1 - q_2) + \left(\frac{1}{\eta_1} - \frac{1}{\eta_2}\right)$$

where ΣY is the total energy yield of the internal and external heat consumptions, including the gas and steam stages referred to 1000 kcal of heat supplied to the external consumer, taking into account the practical limits in the preheating of feed water and mains water. q_1 is the specific heat expenditure for producing energy in the condensing power station replaced by the combined heating and power station ; q_2 is the specific heat consumption on producing power in the combined heating and power station. η_1 and η_2 are the respective efficiencies of a separate heating installation and a combined heating installation.

It is assumed that the condensing power station to be replaced has a specific heat consumption of 2·75 kcal/kWh. It is also assumed that, with a minimum excess-air coefficient of $\alpha = 1{\cdot}15$, the two boiler efficiencies η_1 and η_2 are equal.

In Fig. 4, curve I shows the change in specific heat saving due to the addition of a gas-cycle stage. Curves IIa and IIb show the saving for two variants of a steam-water stage, i.e., IIa for the simultaneous parallel heating of feed water and mains water by exhaust gas (possible only as high values of α), and IIb for the preheating of mains water up to a final temperature of 180° C by steam extracted from the turbine and the heating of feed water by exhaust gas. Curve III shows heat saving as a result of the influence of α on the efficiency of the boiler installation. Curves IVa and IVb show the corresponding total specific savings. The full lines represent the condition of a constant exhaust-gas temperature, of 140° C. The broken lines, drawn only for the variant *b*, are given only for the case when the heating surface of the economiser remains constant, irrespective of α. The magnitude of this surface is so chosen that, at $\alpha = 1{\cdot}9$, the temperature of the exhaust gas is equal to 140° C. With an increase in α beyond 1·9, the temperature of the exhaust gas rises sharply, owing to the increase in the finite temperature difference between the gas and the water in the economiser (the minimum temperature difference at a relatively large gas consumption is obtained on the gas inlet side into the economiser).

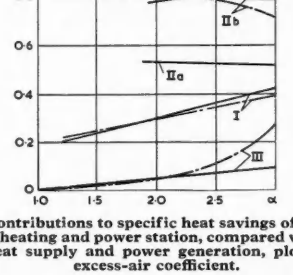


Fig. 4. **Contributions to specific heat savings of a steam-gas combined heating and power station, compared with separate district heat supply and power generation, plotted against excess-air coefficient.**

The following conclusions can be drawn from Fig. 4 :—(1) The gas-steam combined heating and power station, with feed-water heating by exhaust gas only (Curve IVb), gives a large heat saving (approximately 30%) compared with that obtained by the separate generation of power and heat. The saving is larger than that obtained from a system with simultaneous gas heating of feed water and mains water (Curve IVa). (2) Taking into account variation in exhaust-gas temperature with a change in excess-air coefficient (a practically inevitable effect), the curve of the total specific heat saving has a shallow maximum at $\alpha = 1{\cdot}9$ to 2·0. Apparently, the effectiveness of the excess-air coefficient increases with an increase in the efficiency of the gas stage.

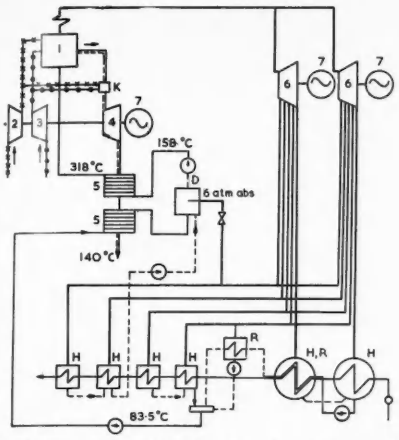


Fig. 5. **Diagrammatic layout of a steam-gas combined heating and power station for district heat supply, with multi-stage heating of mains water by steam extracted from turbines.**

(D) De-aerator.
(K) Auxiliary combustion chamber for maintaining a constant gas-turbine inlet temperature.
Other notation as in Fig. 2.

The results so obtained can be utilised in developing a rational scheme for a combined heating and power station based on a gas fuel of low calorific value and a single-pipe system of heat supply. An example of such a system is shown in Fig. 5. Here, the mains water, in accordance with the conclusions obtained earlier, is heated only by steam extracted from the turbine. Feed water is heated by regenerative preheating at low pressure up to 80° C, and then is led to the water economiser. The latter consists of two stages, between which a high-pressure de-aerator and a feed-water pump are interposed. A scheme for the multi-stage preheating of the mains water is shown in Fig. 5, making use of condensers arranged in series along the flow of mains water and receiving the condensate from two separate turbines.

Altogether, under design conditions, such a gas-steam combined heat and power station, can ensure fuel savings of 8·8% as compared with a pure steam plant. When there is no heat load on the power station, and thus the gas stage does not operate under normal design conditions, the fuel saving is still between 5 and 6%. The net values for savings are even more in favour of the gas-steam system because those of the pure steam plant do not take into account the fan power for boiler draught. Thus, the fuel savings under design conditions and in condensing operation are about 10% and 6·5% respectively.

The advantages of the gas-steam cycle shown in this example of a combined heating and power station for district supply are maintained when the cycle is applied to a power station with conventional extraction turbines. Again, the most advantageous scheme is that in which final heating of feed water is carried out in the gas stage. Depending on the type of heat supply delivered by such installations, the introduction of the gas stage can increase heat economy by a margin sometimes reaching 40%, compared with a similar installation without a gas stage.

The part-load behaviour of a combined heating and power station is most significant when heat delivery depends on ambient temperature. When load is reduced, the gas-steam system, having a constant excess-air coefficient, will be characterised by a reduced flow through the gas turbine, by a reduced gas-cycle pressure ratio, and by a lower gas temperature at the turbine inlet. These variations lead to a sharp reduction in the energy converted in the gas stage, which vanishes at about 30% part load (Fig. 6), leading to a drop in the efficiency of the installation. An increase in excess-air coefficient with a reduction in load, whilst maintaining the gas-turbine inlet temperature, can be achieved at constant compressor speed by means of an auxiliary combustion chamber (Fig. 5). In such a system, the excess-air coefficient must be chosen at its minimum when the load is at its maximum.

In order to vary compressor output, the low-pressure stage of the compressor must be driven at a controllable speed, for instance, by means of a separate driving motor (not shown in Fig. 5).

Characteristic curves for the two types of installations just described are given in Fig. 6. These curves are plotted against the load, measured by the fuel consumption as a percentage of maximum fuel consumption. The first scheme is represented by broken lines, the second scheme by full lines. It can be seen that the first scheme gives higher maximum efficiencies, but that the second scheme has a much better part-load performance. The choice between the schemes will, of course, depend on the conditions of heat supply.

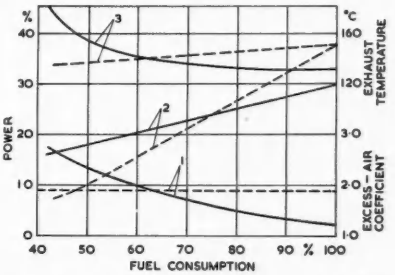


Fig. 6. **Characteristic curves of the gas stage in a steam-gas installation, plotted against fuel consumption (gas of low calorific value) as a percentage of maximum consumption.**

(1) Excess-air coefficient.
(2) Power of gas stage as a percentage of maximum power of steam stage.
(3) Temperature of exhaust gas.

In district-heating schemes for domestic heating under Russian conditions, it is concluded that a higher efficiency at full load is most important, and the reduced efficiency in the summer, when the power station works under condensing conditions, must be accepted.

Detailed analysis of projects shows that, owing to the reduction in the cost of boiler installations, the initial capital expenditure for gas-steam stations does not exceed that for pure steam stations based on gas fuel. The reduction in the cost of electrical energy obtained from the combined heating and power station for district heating by the introduction of a gas stage is about 6%.

The economy achieved with the help of the gas-steam scheme makes it profitable in a number of cases to establish combined heating and power stations in the immediate vicinity of sources of fuel and to arrange the transmission of heat, as well as power, over fairly long distances. A reduction of about 10% in the cost of gas fuel, compared with solid fuel, permits the bridging of an additional distance of about 30 miles over and above that found economical for solid-fuel combined heating and power stations. The further reduction in the operating cost, due to the introduction of the gas stage, increases the additional distance by another 50 miles. Altogether, it would appear to be a profitable proposition to erect such power stations for transmission of heat over distances of up to 90 and even 125 miles. Such distances would seem to be sufficient to enable many urban centres to be supplied with their heating requirements directly from centres of fuel production.

Calculation of Transient Phenomena in High-Voltage Spark Sources

By M. DRAHNÝ. (From *Elektrotechnický Obzor*, Vol. 43, No. 5, May 1954, pp. 253-256, 6 illustrations.)

WHEN designing sources of high-voltage sparks for welding arcs, arc rectifiers, arc furnaces with cooled electrodes, ignition systems of internal combustion engines, etc., difficulties will be encountered in calculating the transient phenomena in the circuits of an induction coil, arranged according to either Fig. 1 or Fig. 2. Such difficulties arise owing to the fact that, even when attenuation is neglected, the behaviour of such circuits depends on six independent parameters (C_1, L_1, M, L_2, C_2, and V or I). The determination of their respective influences is laborious, lengthy, and complex. The method of calculation described in this article reduces the number of independent parameters to two, by using relative values and by taking advantage of certain mathematical similarities ; as a result, the solution can be expressed by a single set of curves, providing a clear description of the behaviour of the circuit.

The problem is to determine whether the potential which occurs on the capacitor C_2 is sufficiently high for a spark to strike across the gap. This potential is produced in the circuit in two ways :—

(1) The capacitor C_1, charged to potential V, discharges into an inductance L_1 (Fig. 1).

(2) The direct current I flowing through the inductance L_1 is interrupted by a contact in parallel with capacitor C_1 (Fig. 2).

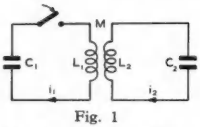


Fig. 1

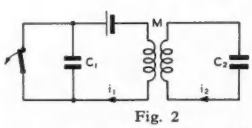


Fig. 2

Fig. 1. **Circuit with capacitor C_1 charged to voltage V.**
Fig. 2. **Circuit with current I flowing through inductance L_1.**

In both cases interest lies in the maximum value E of the voltage e_2 on C_2, which occurs during the transient stage. In the calculation, the ohmic resistances of both windings, as well as the inductances of the leads and connections, are neglected ; this means that all considerations will be valid, provided L_1 and L_2 are of a higher order of magnitude than the loops formed by the leads and connections. In addition, the source voltage is neglected in the circuit shown in Fig. 2, as this is of a lower order of magnitude than the voltage occurring in the circuit during the transient phase. For both circuits, the following system of two linear homogeneous differential equations with constant coefficients will be valid :—

$$\left.\begin{aligned} L_1 i_1' + M i_2' + \frac{1}{C_1}\int i_1 \,\mathrm{d}t = 0 \\ L_2 i_2' + M i_1' + \frac{1}{C_2}\int i_2 \,\mathrm{d}t = 0 \end{aligned}\right\} \quad .. \quad (1)$$

Voltage e_1 is eliminated by changing from the currents i_1 and i_2 to the voltages e_1 and e_2 on capacitors C_1 and C_2. This gives for e_2 the equation

$$(1-\chi^2)\frac{\mathrm{d}^4 e_2}{\mathrm{d}t^4} + (\omega_1^2+\omega_2^2)\frac{\mathrm{d}^2 e_2}{\mathrm{d}t^2} + \omega_1^2\omega_2^2 e_2 = 0 \quad .. \quad (2)$$

where $\chi = M/\sqrt{L_1 L_2}$, $\omega_1 = 1/\sqrt{L_1 C_1}$, $\omega_2 = 1/\sqrt{L_2 C_2}$

The general solution of this equation has the form

$$e_2 = A_1 e^{ja_1 t} + A_2 e^{ja_2 t} + A_3 e^{-ja_1 t} + A_4 e^{-ja_2 t} \quad .. \quad (3)$$

where $a_{1,2}$ are positive, real numbers ;

$$a_{1,2} = \sqrt{\frac{\omega_1^2+\omega_2^2 \pm \sqrt{(\omega_1^2+\omega_2^2)^2 - 4(1-\chi^2)\omega_1^2\omega_2^2}}{2(1-\chi^2)}} \quad (4)$$

The constants of integration $A_{1,\,2,\,3,\,4}$ are determined separately from the initial conditions for each type of circuit.

In the circuit shown in Fig. 1, when $t = 0$,

$$e_2 = 0,\ i_2 = 0,\ e_1 = V,\ i_1 = 0.$$

These initial conditions are equivalent to the relations (for $t = 0$)

$$e_2 = 0,\ \frac{\mathrm{d}e_2}{\mathrm{d}t} = 0,\ \frac{\mathrm{d}^2 e_2}{\mathrm{d}t^2} = \frac{\omega_1^2\omega_2^2}{1-\chi^2} M C_1 V,\ \frac{\mathrm{d}^3 e_2}{\mathrm{d}t^3} = 0$$

With eq. (3), this gives the following values for the constants of integration

$$A_1 = -A_2 = A_3 = -A_4 = -\frac{1}{2(a_1^2-a_2^2)}\frac{\omega_1^2\omega_2^2}{1-\chi^2} M C_1 V.$$

Applied to eq. (3), the final result is

$$e_2 = 2A_1(\cos a_1 t - \cos a_2 t). \quad (5)$$

The voltage e_2 is therefore proportional to the difference between two cosine functions with equal amplitude and frequencies a_1 and a_2 respectively. This difference has a maximum value of ± 2 ; hence, the maximum value of voltage e_2 is

$$E = 4A_1 = \frac{\chi^2}{\sqrt{(\omega_1^2+\omega_2^2)^2 - 4(1-\chi^2)\omega_1^2\omega_2^2}} \frac{2V}{MC_2} \quad (6)$$

This equation is valid, provided that the maxima occur before the attenuation of the circuit, which has been neglected, becomes significant. In other words, it will be valid if frequency a_2 is considerably larger than a_1 ; in this connection, from eq. 4, a_2 cannot be smaller than a_1. Fig. 3 shows the graphic construction of e_2 as the difference between two cosine curves for $a_2 = 10\,a_1$; this condition may be considered a border-line case, because the maximum e_2 begins practically during the period $2\pi/a_1$ from the beginning of the phenomenon.

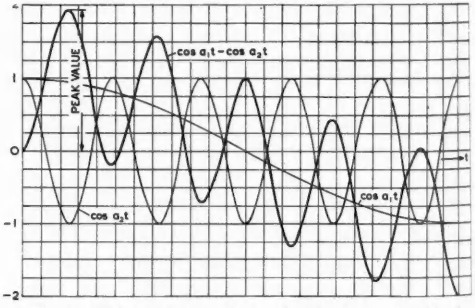


Fig. 3. **Voltage across C_2 in circuit shown in Fig. 1.**

By introducing a " voltage increase factor " $\epsilon = E/V$ and replacing ω_1 and ω_2 by two new parameters, i.e., the ratios of the capacitances and inductances, $c = C_2/C_1$, $l = L_2/L_1$, eq. (6) is transformed into

$$\epsilon = \frac{2\chi}{\sqrt{(c+1/l)^2 - 4(1-\chi^2)c}} \quad .. \quad (7)$$

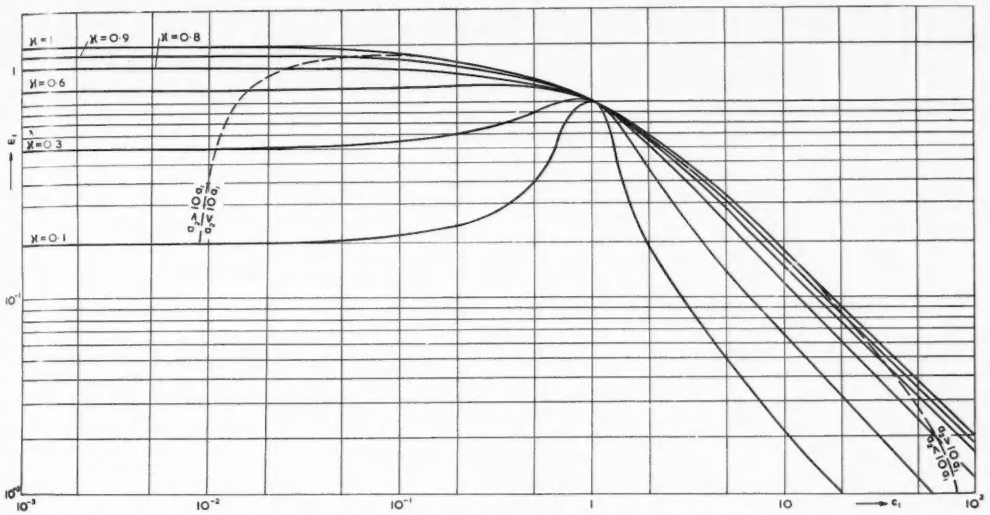


Fig. 4. **Curve $\epsilon_1 = f(c_1)$ for various values of χ. The dotted line indicates the border of the area where $a_2 < 10a_1$.**

Thus, the number of independent parameters is reduced to three, i.e., χ, c, and l.

Use is now made of one important property of the last equation. Let ϵ_1 be the value of ϵ for the parameters $l = l_1$ and $c = c_1$; if ϵ_2 is to be calculated for $l = l_2$ and $c = c_2$, for which are valid $l_2 = k\, l_1$ and $c_2 = c_1/k$, it will be seen that $\epsilon_2 = \sqrt{k}\,\epsilon_1$. This means that a certain mathematical similarity exists. This property can be used to advantage for plotting the function $\epsilon = f(\chi, c, l)$ in a logarithmic scale. Let $l_1 = 1$; then, for the various values of χ, a family of curves is plotted from :

$$\epsilon_1 = \frac{2\chi}{\sqrt{(c_1 + 1)^2 - 4(1 - \chi^2)\, c_1}}$$

This family of curves takes account of all the effects on E of the various circuit parameters (provided that frequency $a_2 > 10a_1$). With the aid of this graph, it is also possible to determine graphically the shape of e_2, i.e., the difference between two cosine curves with amplitudes $\epsilon/2$, provided always that damping can be neglected.

Fig. 4 shows a family of curves ϵ_1 as a function of c_1 for various values of χ. The practical use of the graph will be illustrated in the following example, where E is to be calculated for a circuit with the characteristics :

$L_1 = 1$ mH, $L_2 = 100$ mH, $\chi = 0{\cdot}8$, $C_1 = 0{\cdot}05$ μF, $C_2 = 25$ $\mu\mu$F, $V = 3$ kV.

The values first calculated are :—

$l_2 = L_2/L_1 = 10^2$, $c_2 = C_2/C_1 = 5 \times 10^{-4}$,
$k = l_2/l_1 = 10^2$, $c_1 = k\, c_2 = 5 \times 10^{-2}$

For $c_1 = 5 \times 10^{-2}$, it can be seen from Fig. 4 that $\epsilon_1 =$ F·57, from which

$$\epsilon_2 = \sqrt{k}\,\epsilon_1 = 15{\cdot}7$$

$$E = \epsilon_2\, V = 15{\cdot}7 \times 3 = 47 \text{ kV approx.}$$

The dotted line in the graph indicates the area where the condition $a_2 < 10a_1$ is not fulfilled. This is in the neighbourhood of the point of resonance. The condition of resonance for the variables in this case is $c\, l = 1$, and it will be noted that the point of resonance does not coincide with the maximum value of ϵ.

From the diagram the following deductions can be made with respect to the behaviour of the circuit :—

(1) To achieve a high voltage E, the highest possible value of l is required. It is, however, necessary to keep to the left of the point of resonance, i.e., $c\, l < 1$.

(2) It is possible to increase l either by increasing L_2 (which can be done within wide limits), or by reducing L_1. The limits in this respect are that, according to the original assumption, L_1 must be large enough for the inductance of the leads to be neglected.

(3) l can be increased only at the expense of c, to keep to the left of the point of resonance, where the voltage conditions are more favourable for a not too tight coupling. It is possible to reduce c, either slightly by reducing C_2, or by increasing C_1, and in this respect considerations of energy are the only limitations (a large capacity requires a considerable amount of energy for charging to a sufficiently high voltage V).

(4) Tight coupling is advantageous, unless it has been achieved at the expense of insulation, because an increase in ϵ, obtained by a tighter coupling (above $\chi = 0{\cdot}7$), is small in relation to the increase of ϵ achieved by increasing l.

(5) The conditions $a_2 > 10\ a_1$ can usually be easily fulfilled; consequently, damping presents no danger, and there is no need to achieve the highest possible quality factor for the inductances L_1 and L_2.

(6) Although voltage E is directly proportional to voltage V, it is not necessary to use an unduly high value of V, since the ϵ-values obtained are large.

A circuit of this type was used in these investigations, and a qualitative agreement was found between the measured and the calculated values. Exact measurements are relatively tedious and it has therefore not yet been possible to confirm the quantitative agreement.

The circuit shown in Fig. 2 will be treated similarly.

For $t = 0$,

$$e_2 = 0,\ i_2 = 0,\ e_1 = 0,\ i_1 = I.$$

These initial conditions are equivalent to the conditions (for $t = 0$) :

$$e_2 = 0,\ \frac{\mathrm{d}\, e_2}{\mathrm{d}\, t} = 0,\ \frac{\mathrm{d}^2 e_2}{\mathrm{d}\, t^2} = 0,\ \frac{\mathrm{d}^3 e_2}{\mathrm{d}\, t^3} = \frac{\omega_1^2\, \omega_2^2}{1 - \chi^2} M I$$

With eq. (3), this gives the constants of integration

$$A_1 = -A_3 = j\, \frac{1}{2\, a_1 (a_1^2 - a_2^2)}\, \frac{\omega_1^2\, \omega_2^2}{1 - \chi^2} M I$$

$$A_2 = -A_4 = -\frac{a_1}{a_2} A_1.$$

Applied to eq. (3), this finally gives :

$$e_2 = j\,2\,a_1\,A_1\,[(\sin a_1\,t)/a_1 - (\sin a_2\,t)/a_2] \qquad (8)$$

The voltage e_2 is therefore proportional to the difference between two sinus curves of different amplitude and of frequencies a_1 and a_2 respectively. This difference can assume a maximum value of $1/a_1 + 1/a_2$. Consequently, the maximum E of voltage e_2 is

$$E = 2\,j\,a_1\,A_1\left(\frac{1}{a_1} + \frac{1}{a_2}\right) = \frac{M\,I}{\sqrt{\frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} - 2\sqrt{\frac{1-\chi^2}{\omega_1^2\,\omega_2^2}}}} \qquad (9)$$

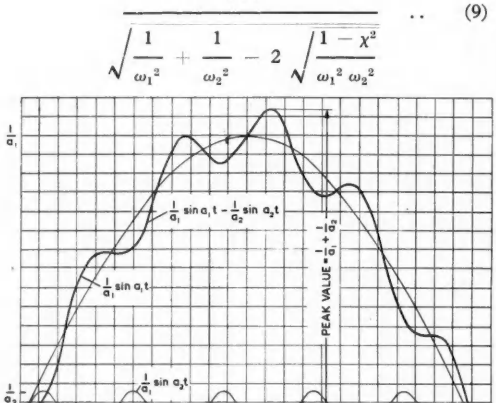


Fig. 5. **Voltage across C_2 in circuit shown in Fig. 2.**

It can again be said that this relation becomes increasingly justified the more quickly the maximum is reached, i.e., the greater the difference between the frequencies a_1 and a_2. Assuming that the damping is sufficiently small and that eq. (9) is valid, at least for $a_2 > 10\,a_1$, the curve for e_2 can be plotted as shown in Fig. 5.

To reduce the number of independent parameters in eq. (9), a method analogous to that shown in respect of ϵ is applied, which transforms eq. (9) into eq. (10), as follows :—

$$\rho = \frac{\chi}{\sqrt{\alpha + \beta - 2\sqrt{\alpha\,\beta}\sqrt{1-\chi^2}}} \qquad (10)$$

whereby the number of independent parameters is reduced to three (χ, α, β) ; a further transformation, similar to that in respect of ϵ, gives

$$\rho_1 = \frac{\chi}{\sqrt{\alpha_1 + 1 - 2\sqrt{\alpha_1}\sqrt{1-\chi^2}}}$$

This function, plotted in a logarithmic scale for various values of χ, gives the curves shown in Fig. 6, and these can be interpreted similarly to the curves shown in Fig. 4 in respect of the first example.

With the aid of these curves, E is determined in the same circuit as before, with, however, an initial current $I = 30$A. The values first calculated are :—

$$\alpha_2 = C_2/L_1 = 25 \times 10^{-12}/10^{-3} = 25 \times 10^{-9}$$
$$\beta_2 = C_1/L_2 = 5 \times 10^{-7}$$
$$k = \beta_2/\beta_1 = 5 \times 10^{-7}$$
$$\alpha_1 = \alpha_2/k = 5 \times 10^{-2}$$

For this value of α_1 the graph in Fig. 6 shows $\rho_1 = 0{\cdot}905$, from which follows $\rho_2 = 1280$ and also $E = \rho_2\,I = 1280 \times 30 = 38{\cdot}4$ kV.

As a point with co-ordinates α_1 ρ_1 in this graph lies near the border of the region where $a_2 < 10\,a_1$, the resultant value of E will to some extent be inaccurate, owing to the damping of the circuit.

For the purpose of designing a practical circuit, the curves do, however, allow useful conclusions to be reached. It will be seen, for instance, that the curves in Fig. 6 show relatively flat maxima for couplings which are not too loose. This is favourable, as it indicates that in this case a deterioration of the tuning of the circuit (as may occur, for instance, when the capacitance C_2 is altered by a change in the position of the feed cable) has no serious effects ; all that is required is to keep to the left of the resonance point (the condition of resonance being $\alpha = \beta$). This is of importance, as there appears to be a tendency in technical literature to consider the resonance point as the optimum operating point, and to underestimate the influence of the degree of coupling.

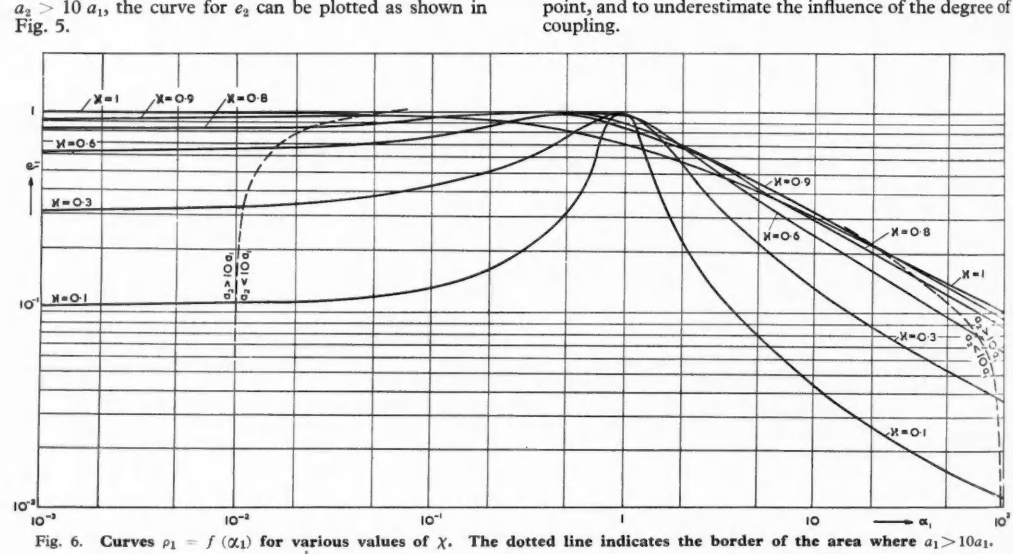


Fig. 6. **Curves $\rho_1 = f(\alpha_1)$ for various values of χ. The dotted line indicates the border of the area where $a_1 > 10a_1$.**

Materials Testing by Betatron Radiography

By R. WIDERÖE. (From *Zeitschrift des Vereines Deutscher Ingenieure*, Vol. 96, No. 15/16, June 1, 1954, pp. 451-456, 17 illustrations.)

NON-DESTRUCTIVE test methods permit the detection of internal flaws in materials at various stages in the production process. In many cases, as, for instance, in welded components and assemblies, non-destructive inspection also gives valuable indications for further manufacturing improvements.

Among these methods, radiography is of particular importance for mechanical-engineering applications. Radiographic inspection was, however, previously limited to steel thicknesses not greater than about 4 in. Greater thicknesses required extremely long exposures and the detection of faults became a difficult and uncertain problem. As many engineering components, particularly in high-pressure technology, reach thicknesses considerably greater than 4 in., the radiographic technique failed just where it was most needed. It was thus necessary to try to increase the penetrative power of the rays.

As a result, X-ray installations were developed for maximum voltages of 1 to 2 MeV, with which it was possible to investigate steel thicknesses of up to approximately 8 to 10 in. Equipment of this type is now in fairly widespread use in the United States, in spite of the high initial expenditure and operating costs.

In 1940, American laboratories produced the first Betatron suitable for practical work. The basic apparatus had been invented two decades earlier. It was soon realised that this new type of electron accelerator offers particular advantages as an X-ray source for the investigation of materials[1]. The facts are that, with a sturdy and not unduly large apparatus, it is possible to produce rays of 30 MeV energy. These X-rays are radiated from a spot of such small area that it can be regarded as a point source for practical work. The rays, owing to their high penetrative power, produce high-definition images and, even with steel thicknesses of 12 in., excellent X-ray photographs can be obtained, which permit faults of 0·04 in. to be clearly identified.

As regards operating reliability and safety, Betratron equipment extensively fulfils the requirements of factory operation, so that wide use of this new equipment in industry may be expected in future. In America, more than a dozen Betatrons are already in constant use. In Europe, the first Betatron built for the investigation of materials will soon be operating. Six other units are already in service and are employed for therapeutic purposes and physical research, as well as for materials testing.

PROPERTIES OF BETATRON-GENERATED X-RAYS.

The Betatron apparatus is very similar to a conventional transformer. As shown in Fig. 1, it comprises a primary winding *a*, excited at 50 cps, which generates in an iron core *b* an alternating magnetic flux. The quarter-period of the ascending portion of the cycle is used to accelerate a stream of electrons in a circular vacuum tube *c*. The electrons are accelerated each time the magnetic field strength increases. After about one million rotations, they reach such a high velocity that their kinetic energy corresponds to a value of 31 MeV.

When this energy is reached, the electrons are impelled by the magnetic field generated by the expansion windings *d* towards a small anode *e* and are there decelerated. In slowing down, a large proportion of their kinetic energy (up to 35%) is converted into electromagnetic radiation, i.e., into X-rays, which are emitted mainly in a tangential direction relative to the circular electron orbit. The radiation is of extremely short wavelength and differs in many respects from conventional X-rays. Betatron radiation is in the form of a very narrow beam, with a maximum in the direction of radiation. The penetrative power of the rays is about 10 times greater than that of a 200-kV X-ray installation. The scatter of rays in materials is extremely small :— Lateral scatter can in practice be measured only for iron thicknesses of more than 8 in., while back-scatter is negligible in most cases.

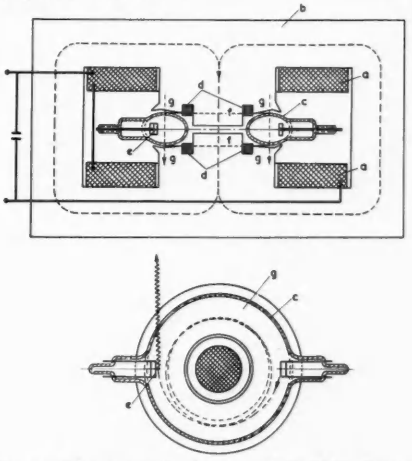


Fig. 1. **Diagrammatic layout of 31-MeV Betatron.**
(a) Primary winding ; (b) iron core ; (c) circular vacuum tube ; (d) expansion windings ; (e) anode ; (f) central poles of magnet ; (g) control poles.

The focal spot is so small (less than 0·1 mm²) that in most cases the limiting value of definition of the recorded images depends only on the shape of the object investigated. This makes it possible to obtain enlarged recordings by increasing the distance between the object and the X-ray film, with defects shown in much greater detail than was previously attainable. More extensive descriptions of Betatrons are given in the literature[2].

Fig. 2 shows Betatron equipment used for the examination of a thick-walled steel body, in this instance a five-ton rotor forging of a hydrogen-cooled 125 MVA genera-

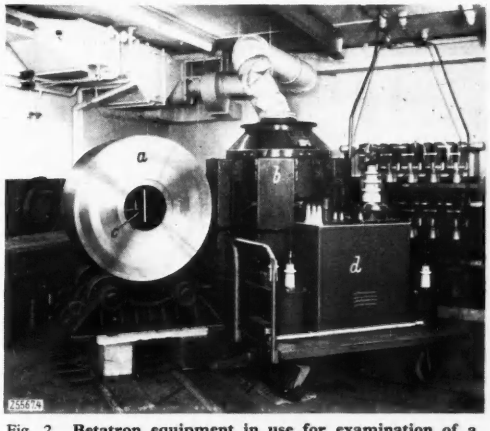


Fig. 2. **Betatron equipment in use for examination of a five-ton rotor foraging.**
(a) Rotor ; (b) Betatron ; (c) film cassette ; (d) power supply.

tor. Ultrasonic tests had indicated the presence of a defect, without, however, being able to identify its nature or extent. Subsequent investigation of the suspected area by means of a Betatron clearly showed a crack of about $\frac{3}{8}$ in. in length and $\frac{1}{4}$ in. in width; this was confirmed when the forging was later sectioned. The thickness of the steel inspected was approximately 15 in., and the exposure was about one hour[3].

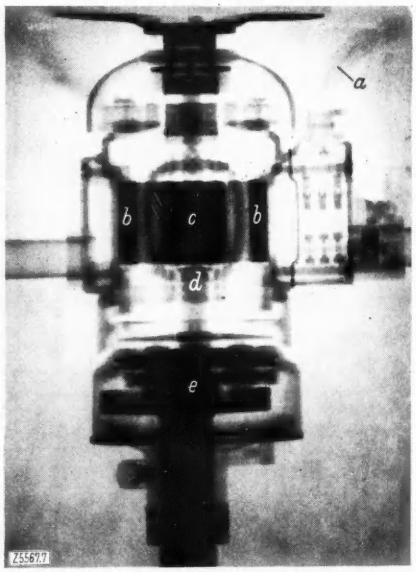


Fig. 3. **Radiogram of an electric hand-drilling machine, taken with 31-MeV Betatron equipment.**
(a) Power lead; (b) stator; (c) rotor; (d) motor shaft; (e) gearing.

A Betatron radiogram of a hand-drilling machine is shown in Fig. 3. The picture of this small machine with a greatest iron thickness of about 4 in. was chosen to illustrate the suitability of high-energy radiography for relatively smaller thicknesses also. Constructional parts, whether thick or thin, are clearly outlined. In the original film, details in the steel shaft of the motor and the thin copper wires in the lead can be recognised. This example shows that in many cases it is possible to inspect completely assembled equipment by means of Betatron radiography. In America, Betatrons are employed for investigations of sealed torpedoes, remote-controlled missiles, shells, etc.[1]

INVESTIGATION OF LARGE THICKNESSES OF METAL.

In materials testing, Betatrons are used mainly to investigate large wall thicknesses. This field presents many new problems.

The decisive feature in radiography is the possibility of identifying defects. This depends on the sensitivity, i.e., the smallest difference in thickness of a metal section which can be detected. In spite of its importance for practical work, the quantitative determination of sensitivity is still a difficult problem. The procedure employed consists in using test objects known as penetrometers (e.g., thin iron wires of various diameters) as standards for identification[6]. The superiority of the 31-MeV Betatron over a conventional 275-kV X-ray equipment is exemplified by the fact that the Betatron identifies a wire of 0·05 in. in diameter behind an iron absorber of about 18 in. in thickness, whereas with ordinary X-rays the detection of such a wire is limited to absorbers with a thickness of not more than $3\frac{1}{2}$ in.

It is necessary, however, to ensure that favourable conditions are obtained for testing. The high penetrative power of the Betatron rays corresponds to a very small absorption coefficient; hence, the relative difference in intensity obtained from a small defect will be correspondingly small. It is only the high definition and practical freedom from scatter of the Betatron that makes it possible to recognise defects of less than 1 mm in thickness, in spite of very small intensity differences. To obtain this result, it is necessary to have a minimum of defects in the X-ray film itself, such as those caused by uneven film emulsion, insufficient precautions in the developing process, inadequate arrangement of lead reinforcements, or unsuitable cassettes.

With Betatron rays, the film emulsion is darkened throughout its thickness, so that a uniform emulsion thickness is necessary. The quality of a radiographic image also depends considerably on the scatter characteristic of the radiation. Lateral scatter not only results in a lack of definition but also reduces intensity differences in the region of a defect[7]. In the energy range of Betatron rays, scatter is mainly caused by the Compton effect. For monochromatic rays, the intensity distribution of photons scattered by electrons can be obtained from the theoretically derived Klein-Nischina formula. However, if attempts are made to apply this formula to scatter in large workpieces, calculation, taking account of the wide range of frequencies in bremsstrahlung, becomes so involved as to be nearly impossible[4]. In this connection, it is of interest to note that the results of an interim report[5] on the subject of a recently completed approximate calculation indicates that this work will be a valuable extension of knowledge on the irradiation of thick bodies.

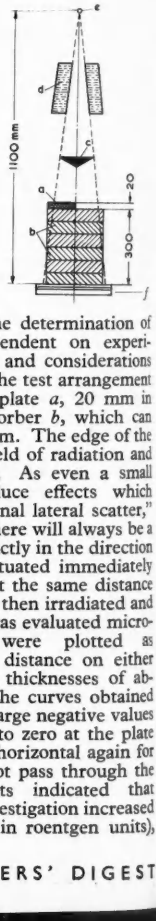


Fig. 4. **Test arrangement for measuring scatter characteristics.**
(a) Steel plate; (b) iron absorber; (c) copper filter for compensation of radiation intensity; (d) diaphragm; (e) focal spot; (f) film cassette.

However, for the time being, the determination of scatter characteristics remains dependent on experimental means. The following tests and considerations are a contribution to this subject. The test arrangement used is shown in Fig. 4. A steel plate a, 20 mm in thickness, is placed on an iron absorber b, which can have various thicknesses up to 300 mm. The edge of the steel plate is in the middle of the field of radiation and exactly parallel to the central rays. As even a small angular misalignment might produce effects which could be misinterpreted as "additional lateral scatter," the edge is slightly twisted, so that there will always be a position along its surface which is exactly in the direction of the rays. The film cassette is situated immediately behind the absorber and is always at the same distance from the anode. The steel plate was then irradiated and the degree of darkening of the film was evaluated microphotometrically. The results were plotted as $2\,\Delta I/\Delta I_{max}$ against x (where x = distance on either side of the steel edge), for various thicknesses of absorber, regarded as a parameter. The curves obtained have a nearly horizontal portion for large negative values of x (under the steel plate), ascend to zero at the plate edge, then rise and tend to become horizontal again for large x-values (where the rays do not pass through the steel plate). Check measurements indicated that darkening of the film used for this investigation increased linearly with irradiation (measured in roentgen units),

so that this darkening is a measure of the radiation intensity behind the iron absorber.

In calculating sensitivity, i.e., the possibility of identifying defects by considering the image on a film, it should be remembered that the intensity differences decrease towards zero only at some distance on either side of the wire, whereas the eye compares intensity differences in the immediate vicinity of the object. For a correct assessment of the visual impression, it is therefore necessary to compare the maximum intensity with the intensity at a short distance, e.g., 2 mm, on either side of the wire. The final sensitivity curve should be calculated on this basis.

Sensitivity, moreover, can be improved very considerably by restricting the size of the field. This is an important consideration in practical work. Thus, for instance, in investigating a welding seam, the field should not be chosen much greater than the width of the weld plus its immediate vicinity. Where sensitivity curves are based on fields of various sizes, the field dimension should always be indicated. In addition, if radiographs are taken larger than full size, by placing the film cassette at a considerable distance behind the object, scatter follows a different pattern and the sensitivity curves deviate from normal.

Stereoscopic X-ray investigation with the Twin-beam Betatron.

The depth of a defect below the surface can be determined by means of two different radiographs. For thin objects this is not so important, but it becomes essential for thick objects. It is probable that in future technicians will increasingly ask for stereo-radiograms to be produced before undertaking many repairs. The method of determining the distance of a defect below the surface is illustrated in Fig. 5. Owing to their high definition, Betatron radiograms examined with a stereoscope give an excellent three-dimensional impression.

The "Wide-Field Stereo Betatron," developed by Brown, Boveri & Co., is specially designed for stereographic work. The apparatus includes two anodes, about 21 in. apart. Electrons rotate alternately towards the left and right, and are directed towards the corresponding anode by special magnetic fields. The two

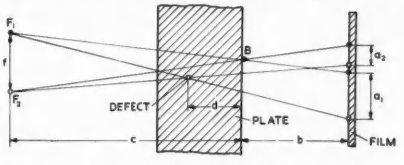


Fig. 5. **Determination of depth of defect by means of two radiographic images.**

F_1 and F_2 = foci; B = reference point.

The depth of the defect is obtained from

$$d = \frac{(a_1 - a_2)\,c}{f(1 + b/c) + a_1 - a_2}$$

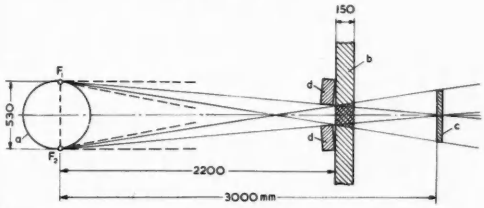


Fig. 6. **Arrangement of beams and film cassette for stereoscopic radiography with the twin-beam Betatron.**

(a) Circular path of electrons; (b) test plate; (c) film; (d) iron diaphragm.

F_1 and F_2 = foci.

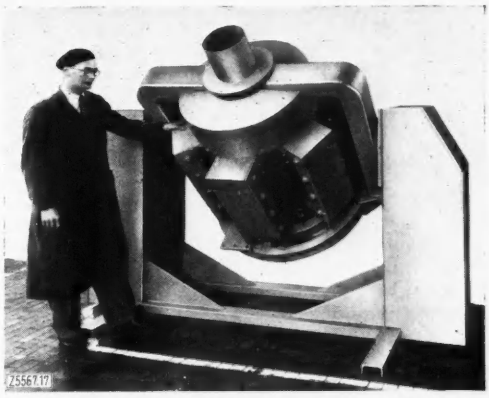


Fig. 7. **Pivoted "Wide-Field Stereo Betatron" (31 MeV max.).**

anodes have a relative angle of 170 deg., so that their beams cross each other at an angle of 10 deg. For wide-field investigations (non-stereoscopic), the film cassette is situated immediately behind the object and the two beams pass through its surface next to each other, so as to obtain a total field of 21 in. For stereoscopic investigations, the beams cross each other before reaching the test surface and the film cassette is placed at a certain distance behind the object (Fig. 6). This procedure thus permits two enlarged stereoscopic images to be obtained simultaneously, side by side.

Three-dimensional investigations carried out on welding seams in thick steel plates indicate very clearly the presence and location of cracks and small fissures. To obtain satisfactory results, the object should have characteristic features which can be easily recognised and compared. Thus, objects with indistinct outlines, horizontal wires, test holes of equal size, etc. are not generally suitable for stereoscopic viewing, either because they do not give a three-dimensional impression or because they are likely to be confused with one

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BIBLIOGRAPHY

(1) J. P. Girard & G. D. Adams: Application of the Betatron to practical radiography. *A.I.E.E. Trans.*, Vol. 65, 1946, pp. 241-246.—G. Elwers: Ordnance using X-rays to inspect complex assemblies, *Iron Age*, Vol. 168, 1951, pp. 95-99.—E. A. Burrill: Modern techniques in high-voltage radiography. *Non-Destructive Testing*, Vol. 11, 1952, pp. 23-27.

(2) P. Waldvogel *et al.*: The Betatron. *Brown Boveri Review*, Vol. 38, 1951, pp. 259-310.—R. Wideröe: The Betatron. *Zeits. Angew. Physik*, Vol. 71, 1953, pp. 187-200.—H. R. Schinz: The Brown Boveri Betatron: Two years of research with the 31-MeV Betatron at the Canton Hospital Zurich. Reprint from *Proc. of 7th Internat. Radiologists' Congress, Copenhagen*, July, 1953, pp. 1-70.—W. Epprecht: Material inspection tests with the 31-MeV Betatron. *Strahlentherapie*, Vol. 89, 1952, pp. 161-174.—O. Vaupel *et al.*: Design and applications of Betatron equipment. *Stahl u. Eisen*, Vol. 73, 1953, pp. 705-721.

(3) A. Von Arx: Betatron and isotope radiography. *Brown Boveri Review*, Vol. 40, 1953, pp. 289-295.

(4) W. Heitler: The quantum theory of radiation. *Oxford U. Press*, 1944.

(5) H. Goldstein *et al.*: Interim report on the NDA-NBS calculations of gamma-ray penetration. *N.C.A. Memo* 15-*C*-20, 1953.

(6) N. C. Miller & G. H. Tenney: Various penetrometer types and their limitations. *Non-Destructive Testing*, Vol. 11, 1952, pp. 28-32.—C. J. Smith: Report on the investigations of Betatron radiographic techniques. *Non-Destructive Testing*, Vol. 11, 1953, pp. 17-22.

(7) N. C. Miller: The art of radiography. *Non-Destructive Testing*, Vol. 11, 1953, pp. 11-15.—R. Wideröe: Further investigations on the industrial use of the 31-MeV Betatron. *Non-Destructive Testing* (to be published).—W. Mauderli: Investigation of some important biological substances and their absorption properties of X-rays. *Fortschr. Röntgenstr. u. Röntgenpraxis*, Vol. 78, 1953, pp. 341-349.

GERMANY

Strain-Gauge Dynamometer for Measuring Cutting Forces

A NEW type of dynamometer for measuring cutting force, used in a recent German investigation into the influence of heat treatment of steels on cutting forces during turning*, is deliberately limited to the measurement of main tangential forces. This is justified by the authors, who state that the total cutting power required can be calculated from the formula $N = P_1 v/(60 \times 102)$, where N = cutting power required [kW], P_1 = main cutting force [kg], and v = cutting speed [m/min]. The feed force can be neglected and the radial force can be estimated approximately by using a simple ratio obtained from a number of check tests.

As shown in Fig. 2, an intermediate disc (10), mounted by means of roller bearings on a tapered sleeve (11) over the lathe spindle, is interposed between the lathe dog and the driver, and is intended to allow for the small relative movement of the component caused by the minute deflection of the driver. In practice, three drivers, each of different thickness, are installed, to cover a measuring range from 1·0 to 150 kgm, and, when assembled, their ends engage in corresponding apertures in disc (10). Two of these drivers, (4a) and (4b), are visible in Fig. 2. One driver is selected for any one test and is then engaged mechanically and connected to the

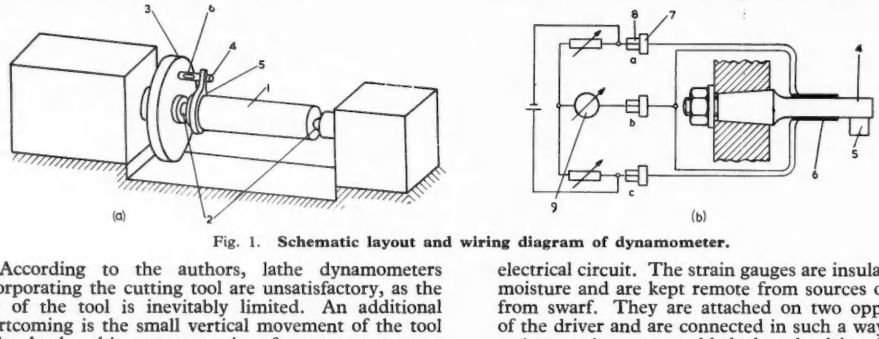


Fig. 1. **Schematic layout and wiring diagram of dynamometer.**

According to the authors, lathe dynamometers incorporating the cutting tool are unsatisfactory, as the size of the tool is inevitably limited. An additional shortcoming is the small vertical movement of the tool under load; this movement is, of course, necessary, inasmuch as the measurement of the force is generally based upon it. In the new dynamometer, which uses strain gauges, the cutting tool is held in the tool post in the normal way. The component is supported between

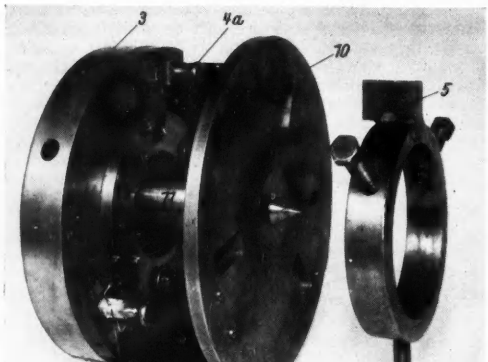


Fig. 2. **View of dynamometer and lathe dog (5).**
For clarity, disc (10) is shown separated from face plate (3).

centres, and the measuring point is transferred from the tool to the lathe dog, as shown schematically in Fig. 1a. From component (1), held between centres (2), the cutting force is transmitted to face plate (3) and lathe dog (5), *via* driver (4). This driver, which is subjected to a bending strain as the result of the cutting force transmitted to it through the lathe dog, is provided with strain gauges (6). The strain is indicated on the meter (9) of a Wheatstone-bridge circuit, which is connected to the strain gauges *via* slip rings (7) and brushes (8), as shown in Fig. 1b.

*O. KIENZLE and H. VICTOR: *Stahl und Eisen*, Vol. 74, No. 9, April 22, 1954, pp. 530-539, 16 illustrations.

electrical circuit. The strain gauges are insulated against moisture and are kept remote from sources of heat and from swarf. They are attached on two opposite sides of the driver and are connected in such a way that their resistance changes are added when the driver is strained; they are, however, unaffected by temperature variations.

The bridge circuit measures statically and indicates the required average value of the short-period fluctuations of the main cutting force. The measuring unit is calibrated with weights, and the calibration curve of the whole installation is strictly linear. Repeatability of measurements is within $\pm 2 \times 10^{-6}$, so that the overall inaccuracy, even at the lowest of the three measuring ranges and allowing for the resistance of the slip rings, does not exceed $\pm 1\%$. The measured value will include any difference in contact resistance between brushes (8a) and (8c) (see Fig. 1b); this, however, can be neglected, in view of the 120-ohm resistance of the strain gauges. The calibration-curve variation, after the drivers had been removed and later re-installed, was found to be less than 1%, and no measurable change in accuracy was observed after three years of use.

MATERIALS TESTING BY BETATRON RADIOGRAPHY

(*Concluded from previous page*)

another. However, a natural crack, even of very small size, or extending in a horizontal direction, is easily and immediately recognised in the thickness of a steel plate. Enlarged stereo-radiograms of fine cracks made with this machine are particularly impressive.

The main field of application of this new method of inspection is in continuous production processes and in final inspection, but it also offers interesting possibilities in metallographic research.

For the testing of high-pressure vessels, the equipment (Fig. 7) is mounted so as to be able to pivot in a horizontal direction on a carriage which can be moved on rails along the welding seam to be investigated. The film cassette is located inside the vessel. For special work, the apparatus can also be tilted. For the investigation of circular seams, the pressure vessel is rotated about its axis. The equipment is provided with full protection against radiation and, as only secondary radiation of low intensity must be taken into account, the safeguarding of personnel presents no particular difficulties.

Cost Accountancy in the Engineering Industry

By S. Howard Withey, F.B.S.C.

An analysis of the audited accounts of engineering companies covering the past year's operations shows that directors are finding it increasingly difficult to make adequate provision for the decline in the capital value of productive equipment, and that in many instances the balance-sheet value of fixed assets bears little relation to the amount of unrecovered investment in respect of which the owners expect, sooner or later, to be reimbursed. Some managements have been obliged to defer consideration of the problem of depreciation, while others have deemed it sufficient to reserve convenient round sums to meet the unavoidable shrinkage in the value of plant and machinery; altogether, there is a very noticeable lack of uniformity in methods of accounting.

Where considerable capital expenditure is involved, the acquisition of additional equipment calls for the widest information in regard to individual units and their capabilities. Sections of plant may be eminently suitable and dependable for a specific purpose but, unless there is a well organised spares and maintenance service, it may be impossible to raise productivity, reduce costs, and improve the quality of products. Costs of engineering production may be adversely affected if equipment which is smooth and positive in action and has ample reserves of power and speed is not operated on expert advice. Fortunately, however, such technical advice is now freely available.

Engineering work often begins with the production of small sub-assemblies, and progresses through a series of operations employing assembly tools and fixtures increasingly larger in dimensions until completion. Where speed, fast penetration, and easy handling are essential, the decision of the British Government to introduce a new system of investment allowances for expenditure on plant and machinery is expected to stimulate capital outlay and to add substantially to the demand for engineering products on overseas account. There has been a gradual improvement in the British export credit system, and the latest development is the decision to grant direct cover to bank loans against approved capital goods exports. Engineering firms, for better performance and production economy, have reserved substantial sums for re-equipment and development, and commitments for additional capital expenditure are now on a much larger scale; in many cases the introduction of new processes will involve higher charges for depreciation and other deteriorating factors.

Although decreases in the value of engineering equipment are very frequently the result of actual physical deterioration, they may be caused by developments in science, research, and invention. Engineers constantly design plant and machinery calculated to ensure a longer life of useful service and to reduce production costs, while new and improved methods of handling have recently been devised. Thus, for example, systems of positive centralised lubrication to measure, control, and supply the exact amount of oil required by every bearing are now being applied, while the range of engines to provide lower noise levels, cheaper running costs, and prolonged efficiency in operation has widened considerably; nevertheless, many firms concerned with the production of capital goods are reaching that stage where their fixed equipment cannot be employed without waste, loss of output, and idle machine hours.

ALTERNATIVE METHODS OF COMPUTATION AND ACCOUNTING

The amount of capital invested in engineering equipment is, of course, very substantial; while some installations are often scrapped long before they have lost their market value, other units and groups can be employed to give satisfactory results over extended periods, and in deciding rates of annual depreciation a considerable degree of specialised knowledge is now demanded. It is true that many engineers maintain elaborate records of their capital expenditure; it is equally true that losses arising from the inevitable decline in the value of engineering equipment are not being subjected to anything approaching uniform or scientific treatment in accounts and costings.

In some instances, for example, an equal proportion of the first or original capital cost of acquisition and installation is written off each year and debited to depreciation account in such a way that, at the end of a nominated period, the book value of the equipment will be reduced to nil or to a purely nominal figure. This "straight-line" method of computation and accounting is usually applied when the cost of upkeep and maintenance is not likely to vary materially as between one period and another; in cases where equipment maintenance costs are steadily expanding, with a gradual decline in capital value, it is often deemed advisable to adopt a method of computing depreciation which would have the effect of equalising the combined charge for inclusion in the costs, the progressive reduction in the depreciation charge providing some or all of the margin needed to meet growing upkeep costs.

In many instances an important factor to be taken into consideration is interest on capital, particularly when funds have been raised for the specific purpose of installing new or additional equipment. In this connection it is now becoming the practice to increase the book value of certain assets by the addition of interest calculated at a fixed rate, and to spread the total burden over a pre-determined period in the form of equal annual instalments against profits. Units and groups of plant which are difficult or impossible to assess by either "straight-line" "percentage," or "annuity" methods may be subjected to periodical revaluation on the part of an unbiased expert, the decline in capital value, if any, being charged against standing orders.

Items to be capitalised can be readily collected in the form of monthly or other periodical totals for ledger-posting purposes, by using a pattern of purchases journal or bought day-book, provided by the printer with a sufficient number of columns or sections to enable the capital expenditure to be suitably classified. In addition to these records, it is advisable to maintain a detailed inventory of the entire productive equipment, this being preferably divided into sections to correspond with varying types, specifications, and capacities. Each entry made in this inventory should give the date, as shown on the relative invoice or other debiting document, the name of the maker or supplier, and a sufficiently detailed description to enable the particular equipment to be readily identified. Apart from proving of considerable value and utility to the management and staff, such information greatly facilitates matters at audit time and, when drafting a balance sheet, exhibits a correct view of the financial position.

The "Straight-line" Method, as Applied to Presses, Pumps, and Bending Rolls.

Pumps of varying ranges with motors and automatic accessories now give very reliable performance, while presses and plate-bending rolls and tube-bending machines are extremely economical to maintain; however, in order to make way for the capitalisation of modern units and groups of engineering equipment, it is inevitable that the book value of all existing plant and machinery will have to be written off and charged against the operations. Unless, therefore, a greater degree of uniformity in accounting methods is established, it

cannot reasonably be expected that engineers will be able to obtain the maximum allowances to cover depreciation, and this emphasises the importance of applying the most suitable methods of computation.

Although the highest value that can be placed on groups and sections of engineering machinery and auxiliary equipment consists of the first or original book value of the installations, plus transport charges and any foundation expenses, the conditions under which specific equipment is being worked must be taken into consideration. The lowest value will be that of the material and components; computations of depreciation are often based on the difference between these two extreme figures and may be complicated by wide variations in the nominated service or useful life of capital additions.

For example, the presses, pumps, and plate-bending rolls employed by a firm of engineers were shown in the books at £83,800 as at December 31, 1952, and made up as follows :—

	£
Presses	32,800
Pumps	18,500
Plate-bending rolls	32,500

The presses included clipping, foot-lever, friction-screw, hydraulic, and blanking presses, and, owing to the nature of the operations to be undertaken, it was estimated that at the end of another five years they would have to be included in the balance sheet at a value not exceeding £10,000. It was also agreed that the centrifugal, hydraulic, and vacuum pumps would be worth about £12,500 in ten years time, and that the plate-bending rolls would still have a value of something like £20,500 at the end of twelve years. This firm had considerable liquid resources and was in a position to modernise and re-equip without having to seek special banking facilities.

A scheme of development was approved, based on the prices prevailing at the time, and was expected to be completed by the end of the present year. This programme was expected to cost £100,000, of which a total of £66,500 was to be spent on new presses, pumps, and bending rolls.

In January 1953, several new-type presses, varying in weight from 45 cwt to 150 cwt, were acquired on credit terms at an invoiced cost of £30,000 and, after consulting with the makers, it was decided to write off depreciation in such a way that at the end of ten years the book value of these additional assets will be about £17,500. In March 1953, additional pumps were ordered and new expenditure on plate-bending rolls sanctioned; in due course the cost prices were recorded in the firm's purchases journal and transferred from the "capital outlay" column to the debit side of a "Presses, Pumps, and Rolls" account opened in the impersonal ledger. When all the items had been properly dealt with in the books of account, the asset account showed a debit balance of £150,300, as follows :—

	Book Value Dec. 31 1952	Additions 1953	Total Value
	£	£	£
Presses ..	32,800	30,000	62,800
Pumps ..	18,500	26,500	45,000
Rolls ..	32,500	10,000	42,500
	£83,800	£66,500	£150,300

To simplify matters, it was decided to spread the capital cost of the new pumps to show a balance of £12,500 at the end of ten years, and to deal with the additional rolls in such a way as to leave a balance of unrecovered investment of £2,500 at the end of twenty years. As it was considered likely that the cost of repairs and maintenance would be fairly uniform, as between one operating period and another, and it was desired to incorporate a standard figure for depreciation in the engineering costs, the annual charge was arrived at as follows :—

COMPUTATION OF DEPRECIATION
(" Straight-Line " Method)

	Depreciation £
Presses :—	
(a) *Original:* One-fifth of £22,800, i.e., book value as at Dec. 1952, £32,800, *less* estimated value 5 years hence, £10,000	4,560
(b) *Additions:* One-tenth of £12,500, i.e., book value as at Dec. 1953, £30,000, *less* estimated value 10 years hence, £17,500	1,250
Pumps :—	
(a) *Original:* One-tenth of £6,000, i.e., book value as at Dec. 1952, £18,500, *less* estimated value 10 years hence, £12,500	600
(b) *Additions:* One-tenth of £14,000, i.e., book value as at Dec. 1953, £26,500, *less* estimated value 10 years hence, £12,500	1,400
Plate-Bending Rolls :—	
(a) *Original:* One-twelfth of £12,000, i.e., book value as at Dec. 1952, £32,500, *less* estimated value 12 years hence, £20,500	1,000
(b) *Additions:* One-twentieth of £7,500, i.e., book value as at Dec. 1953, £10,000, *less* estimated value 20 years hence, £2,500	375
Total Depreciation	£9,185

At each annual stocktaking, the asset account will therefore be credited with £9,185 and the firm's depreciation account debited with a like amount; consequently, at the end of five years, the "Presses, Pumps, and Rolls" account will show the following entries :—

Debit	PRESSES, PUMPS, AND ROLLS A/C		Credit
Dec. 1952	£	Dec. 1954	£
To Balance brought down	83,800	By Depreciation written off	9,185
Dec. 1953			
To Additions to Date	66,500	By Balance	141,115
	£150,300		£150,300
Dec. 1954		Dec. 1955	
To Balance brought down	141,115	By Depreciation written off	9,185
		By Balance	131,930
	£141,115		£141,115
Dec. 1955		Dec. 1956	
To Balance brought down	131,930	By Depreciation written off	9,185
		By Balance	122,745
	£131,930		£131,930
Dec. 1956		Dec. 1957	
To Balance brought down	122,745	By Depreciation written off	9,185
		By Balance	113,560
	£122,745		£122,745
Dec. 1957		Dec. 1958	
To Balance brought down	113,560	By Depreciation written off	9,185
		By Balance	104,375
	£113,560		£113,560
Dec. 1958			
To Balance brought down	£104,375		

The balance of £104,375 will be included on the assets side of the firm's balance sheet dated December 31, 1958, and will represent the following :—

Presses :—	£62,800 — 5 (4560 + 1250)	= £33,750
Pumps :—	£45,000 — 5 (600 + 1400)	= £35,000
Rolls :—	£42,500 — 5 (1000 + 375)	= £35,625
		£104,375

(To be continued)

A Fully Supercharged Generator

By S. Beckwith and L. T. Rosenberg. (From *Electrical Engineering*, Vol. 73, No. 5, May 1954, pp. 435-440, 10 illustrations.)

The fully supercharged generator described in this article has virtually no load limit imposed by heating. It is simpler and more rugged than its partially supercharged predecessor with internal cooling of the rotor windings only, and permits substantial savings in power-plant space and costs.

Several generators with internally cooled rotor windings are in operation, the first having been installed more than two years ago. The first fully supercharged generator with internal cooling of both rotor and stator windings has now been built.

Supercharging does not merely entail the use of somewhat higher cooling velocities than normal. Since it involves a gas passage the full length of the rotor and stator coils and core, no load whatever can be carried with conventional gas pressures and cooling-medium mass flows. It is not until the mass flow of cooling gas is sufficient to absorb the no-load losses that even no-load operation is possible. From this point on, however, doubling the mass flow of the cooling gas substantially doubles the amount of losses which can be absorbed for a given temperature rise.

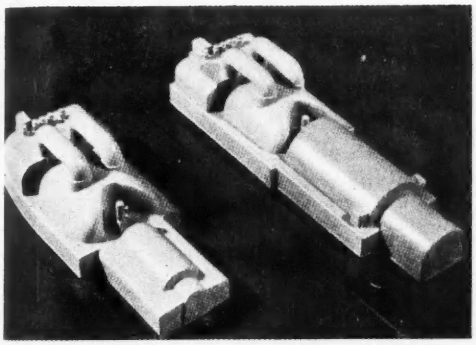


Fig. 1. **Scale models of a supercharged unit and a conventionally cooled unit of equal rating.**

When the gas pressure in the housing is substantially atmospheric, the cooling fans in the generator must produce many times the pressure hitherto used in non-supercharged cooling. If the gas pressure in the housing is raised to two or three atmospheres, then, since the density of the gas is increased, the volume of gas required is decreased, and fan pressures are reduced to a magnitude which can be obtained by special blowers.

The machine described has adequate cooling, so that the limit in its ratings is not a thermal one, but is determined by efficiency. In other words, its name-plate rating was selected so that its efficiency would be as good as or slightly better than that of any normally designed machine now in production. Its light-load efficiencies are improved, owing to the smaller proportion of fixed loss, compared with those of conventionally cooled generators.

The new machine has a rating of 40 MW and operates with a gas pressure of 30 psig. The large saving in size and consequently in power-plant cost can be appreciated from Fig. 1, which shows the scale model of this unit next to that of a conventionally cooled unit of equal rating. The overload MW-rating of the new unit is limited only by the capacity of the turbine ; the overload rating in MVA is limited only by the size of the exciter and by the gas pressure used, and will probably be 60 to 70 MVA at 45 to 60 psig.

Stator-coil cooling.

Stator-coil cooling is effected by rectangular metallic tubes in the centre of the coil, as shown in Fig. 2. These tubes are each the depth of several strands and consequently should be made of high-resistance material, such as monel metal or stainless steel, to keep eddy-current losses low.

Cooling by means of hollow strands was considered, but was not adopted because it requires deeper strands and, in consequence, results in greater eddy-current loss. This conclusion is the reverse of that reached on the rotor, where only direct current is involved and deep conductors may be employed, permitting ducts in the rotor copper, as shown in Fig. 3.

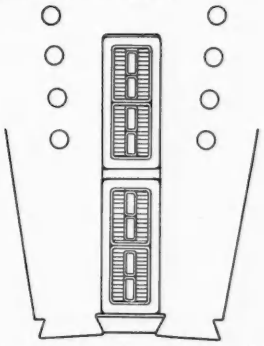


Fig. 2. **Cross-section of stator slots.**

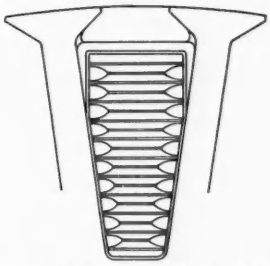


Fig. 3. **Cross-section of rotor slots.**

With this type of cooling, radial stator vents are no longer required, and the stator iron is stacked solidly from one end of the core to the other. The extra stator area of 25% which thus becomes available for magnetic flux cannot be utilised fully for this purpose and is therefore largely available for use in making the stator slots wider, making up for the space occupied by the ventilating tubes in the stator coil.

Stator-core cooling.

The stator core is cooled by small holes in the stator laminations, which stack up to give lengthwise gas passages through the stator core. The size of these holes is co-ordinated with the size of the stator-coil cooling ducts, so that full use is made of the available gas pressure and adequate cooling surface is available for contact with each lamination. The use of high gas velocities and contact with every lamination will give high uniformity of cooling and will avoid the high thermal resistance encountered when heat is conducted perpendicular to the stator laminations.

ROTOR-COIL COOLING.

Rotor-coil cooling on this machine also uses end-to-end gas flow. This is a considerable improvement mechanically on previous supercharged rotors, as it eliminates the need for gas-discharge ducts in the centre of the rotor. However, doubling the gas-passage length makes fan pressure requirements eight times as great. In the first place, twice as much heat must be picked up by the gas entering the duct, as it continues twice as far and can rise only to the same safe temperature limit. In the second place, the duct is twice as long, The fan volume requirement does not need to be increased, as the same total heat loss is absorbed by the gas. In a machine with conventional cooling, doubling the machine length ordinarily merely doubles the delivery requirements of the fan and does not increase pressure requirements, as parallel paths can be used.

As shown in Fig. 4, the gas for the rotor ducts is taken directly from the pressure chamber at the turbine end of the machine through openings below the end disc and then into the rotor-coil ends. The gas enters the rotor coils at alternate diagonal corners, and as much gas as possible is by-passed around the coil end and is admitted to the coil at the end of the core. While this procedure makes the coil ends at the entering gas end slightly hotter, it improves cooling at the outlet end of the machine, as it provides a 5 to 10% greater gas flow.

It will be noted from Fig. 3 that the rotor slot is tapered and that the rotor tooth has parallel sides. This somewhat unusual design was found desirable on the basis of a study on magnetic saturation and made possible by the fact that, since the rotor copper was made lighter by the amount of copper machined away for the cooling ducts, the slot could be made wider, without increasing the slot-wedge stress or depth.

AIR-GAP COOLING.

The rotor stray losses, the rotor windage loss, and part of the stator-tooth loss are taken care of by gas in the air gap. This gas is controlled, as has been done before, by a restricted clearance at the end of the air gap. However, in this case, the restriction is more drastic because of the smaller fraction of losses which are taken to the gas in the air gap and because of the larger air gap. This small gas flow through a large air gap and consequent low axial gas velocity do not handicap cooling.

COOLERS.

When coolers for a supercharged machine are considered, the first preference is for a cooler extending from one end of the machine to the other and having lengthwise flow. This so co-ordinates the cooler with the axial gas flow through the generator that, in passing through the cooler, the air is returned from one end of the machine to the other and almost no ducts are required. The second design factor is to have a cooler which makes use of the extra pressure drop available. In a conventional design, the coolers may absorb 20% of the pressure produced by the cooling fan. In a supercharged machine they may absorb only 10% of the total fan pressure, though this 10% is a much greater pressure drop than 20% of normal fan pressure.

The coolers used incorporate both desirable properties, i.e., axial gas flow and a moderate pressure drop. Although seldom used hitherto in rotating machines, they are standard coolers, on which much experience was available in other services. They have cooling fins which are parallel to the tubes, and they have bayonet-type concentric tubes, so that both water heads are on the outboard end of the machine. Special provision for expansion and contraction is not required with this construction, and cleaning can be effected without removing hydrogen from the generator. As the kilowatt loss of the machine is the same as that of a standard machine, it has not been possible to reduce the overall size of the coolers in proportion to the overall size of the generator frame. However, an appreciable gain was achieved by using higher velocities and gas-pressure drops in the cooler. A very considerable reduction also was made in cooling-water requirements for the coolers, because the higher outlet temperature and the higher gas velocities permitted the cooling water to absorb about twice as many kilowatts per gallon per minute as is done normally. The cooling water requirements are thus only half those of a conventional machine.

CREEPAGE STRENGTH OF STATOR-COIL ENDS.

A supercharged stator coil has cooling gas entering the coil at the U-bend on one end of the generator and discharging at the U-bend on the other end. The points of gas entrance and exit necessarily must be those where the interior of the cooling ducts or tubes in the stator coils is exposed to the cooling gas. Thus, there is substantially bare conductor metal at each U-bend, and adequate provision must be made in the design for creepage and flash-over strength between turns, between adjacent coil U-bends, between phase belts, and from U-bend to ground.

To explore the possibility of using helium as an alternative to hydrogen cooling, tests were carried out with these two gases, as well as with air. These indicated that, above 18 psig, the creepage breakdown strength in hydrogen is higher than in air at atmospheric pressure; in helium, at 45 psig, it is less than in air at atmospheric pressure, but the machine has been designed to take this into account and to permit safe operation in helium at this pressure.

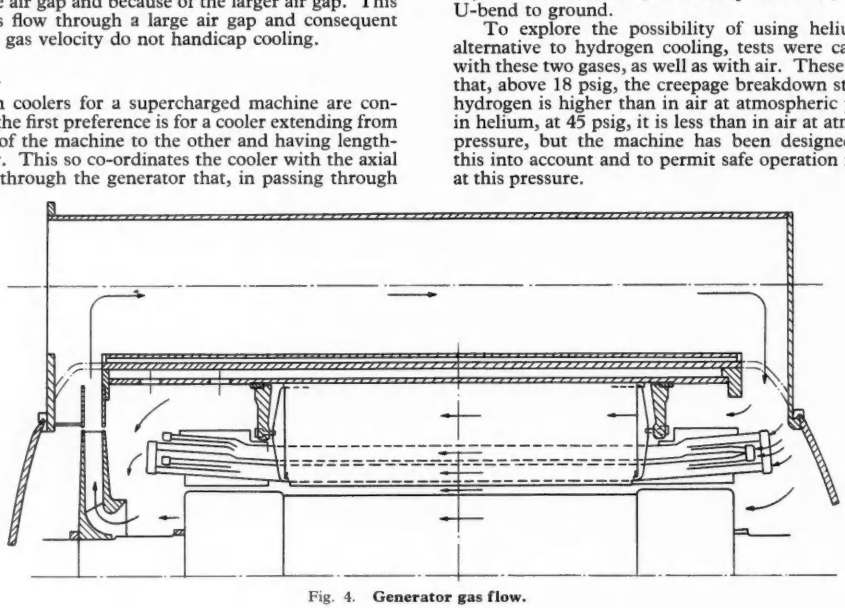


Fig. 4. **Generator gas flow.**

BLOWERS.

The blower used resembles a conventional compressor wheel and is mounted on the outboard end of the shaft, so that it does not interfere with rotor removal. The entrance and exit conditions of the blower are, however, not quite the same as on a conventional blower. The entrance gas has some pre-rotation, because part of it is coming directly from the air gap of the machine and part from the rotating end disc of the rotor. Furthermore, the rotor end, shaft, and blower cover-plate tend to rotate the remaining air by surface-friction effects. To minimise these effects, a stationary shroud in front of the blower wheel is used. However, as a result of exhaustive tests and partly by the use of cooling gas at 30 psig, it was possible to have a single-stage blower instead of the double-stage blower used on the machine now in service with rotor supercharging only.

POWER-PLANT SAVINGS.

The short rotor-removal distance of this 40 MW machine will save 10 feet of power-plant width, with a corresponding reduction in crane span and lifting capacity, where the stator is the heaviest piece to be handled. The stator weight for this new design is only a fraction of that for conventional cooling. The corresponding reduction in plant width for a 150-MW unit would be 22 feet, and at least 11 feet of foundation length can also be saved. The weight and size reduction permits complete factory assembly of the largest machines and shipment without dismantling.

The 2-pole fully supercharged machine has reactances almost identical with those of a large 4-pole generator. When full advantage is taken of the higher subtransient reactance, further savings may be possible in switchgear selection.

CONCLUSIONS.

This completely supercharged generator takes full advantage of increased gas pressures, and has virtually no load limit because of temperatures. Its axial core length is less than half that of the equivalent conventionally cooled machine, and its average and differential temperatures are lower, greatly reducing the seriousness of differential expansion.

By utilising the internal space more effectively, the quantity of gas in the fully supercharged generator has been cut in the ratio of 5 to 1 from the volume of its conventional predecessor. Its small bearings and seals minimise lubrication requirements, hydrogen consumption, and mechanical maintenance. The reduction in size and weight permits factory assembly of the largest machines and also affords substantial economy in power-plant space and costs.

SWEDEN

Self-Ignition of Oil-Ash Deposits

By I. WIVSTAD. (From *Teknisk Tidskrift*, Vol. 84, No. 24, June 15, 1954, pp. 557-560, 10 illustrations.)

In a number of cases where heavy residual oil has been used as a fuel, self-ignition of the deposits has occurred in recuperative and regenerative air preheaters, both new and old, causing fires.

To clarify the problem of self-ignition of oil-ash deposits in recuperative and regenerative preheaters, a series of laboratory tests was carried out in an electric muffle furnace (Fig. 1). Ash samples were put into asbestos bowls standing on an asbestos board, which in turn rested on laths. The temperature of the samples was measured by means of a radiation pyrometer connected to a 10-second recorder.

Self-ignition temperature was determined by raising the furnace temperature at an average rate of 200° C per hour. At the self-ignition point, the temperature of the samples rose so sharply that a marked kink resulted in the time/temperature curve, while the furnace-temperature curve continued in a straight line.

Self-ignition may take two different courses, as shown in Fig. 2. In a small, localised ash deposit, self-ignition occurs when the temperature exceeds a certain value, at first giving rise to intense surface combustion.

In a larger deposit, a fire may occur at a considerably lower temperature, owing to slow internal oxidation. Self-ignition is possible only if the deposit is relatively thick and releases but little heat to its surroundings. Once the process is well launched, the temperature rises and combustion is accelerated.

The relation between self-ignition temperatures and composition was investigated in an oxidising atmosphere on 2-gram samples taken from an oil-fired steam boiler. Oil data were as follows :—

Specific gravity at 20° C ..	0·94
Viscosity at 50° C	50 centistokes
Sulphur	1·8%
Ash content	0·04%
Effective calorific value ..	9770 kcal/kg

Ash composition :—C, 54% ; Fe, 16·1% ; V, 2·3% ; Na, 0·2% ; S (total), 4·4% ; S (as free H_2SO_4), 0·9%.

The self-ignition temperature of the oil ash was 400° C, and of the fuel oil or mixtures containing 40% or more oil, 245° C. Mixtures containing ash, soot, and only 30% of oil ignited at the latter temperature,

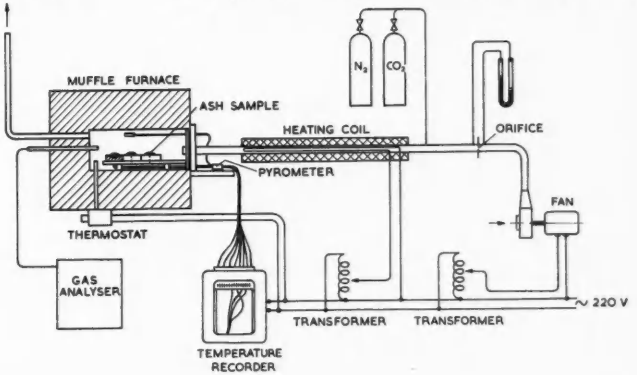


Fig. 1. **Apparatus for testing self-ignition of ash deposits.**

while various combinations of ash and soot range between 400 and 360° C.

Additives, such as sodium sulphate, sodium pyrosulphate, sodium carbonate, iron oxide, etc., generally increased self-ignition temperature. Some caused slight reductions, but never below 245° C.

The oil contained in the deposits of a steam boiler is probably an evaporated product of the original oil. Tests with oil evaporated at up to 360° C, with a loss of 40%, gave somewhat lower self-ignition temperatures than the original oil, and it may therefore be assumed that the same applies to the actual deposits.

Action of Atmospheric Oxygen on Small Deposits.

Tests with varying oxygen content in the furnace showed that, with a content of 21%, the temperature of the samples was always 150° C above that of the furnace atmosphere while, with an oxygen content of only a few per cent, the difference was approximately 10° C.

Self-Ignition by Slow Oxidation.

In larger deposits, in contrast with the foregoing results, an exothermic process may take place by slow oxidation at lower temperatures. Tests with 25-gram samples showed that the lowest ignition temperature was 160° or 85° C below the self-ignition temperature of small deposits. For an ash deposit whose self-ignition temperature was 400° C, the corresponding value was 250° C, or a drop of 150° C. Hence, the self-ignition temperature does not represent the limit beyond which an ash deposit must not be heated because, for example, if a heavier deposit is formed in a portion of a regenerative air preheater, its interior will cool only slightly, so that a slow oxidation process may lead to an exothermic process.

Action of Atmospheric Oxygen on Large Ash Deposits.

The lowest temperature at which slow oxidation can lead to an exothermic process depends on equilibrium between the heat produced and the heat released. This temperature can therefore be increased by reducing the amount of heat produced in the deposit, e.g., by reducing the oxygen content of the atmosphere. Tests with oil-ash samples (25 gr) in an atmosphere with a varying oxygen content (Fig. 3) showed that, when the content was below 7·5%, no excess temperature could be observed in the samples, but when it was higher, their excess temperature rose in proportion. If the ambient temperature was raised to 350° C, the oxidation process became exothermic, as soon as oxygen was present in the atmosphere. Thus, the lowest temperature at which a large ash deposit can give rise to an exothermic process varies with the oxygen content of the atmosphere, as shown in Fig. 4.

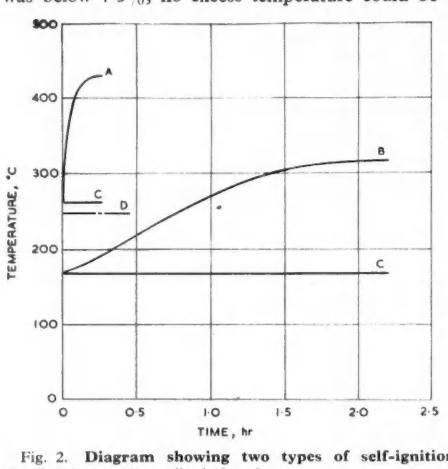


Fig. 2. **Diagram showing two types of self-ignition.**
(A) Self-ignition in small ash deposits.
(B) Ignition by slow oxidation in large ash deposits below the self-ignition temperature of the deposit.
(C) Furnace temperature.
(D) Self-ignition temperature of ash deposit.

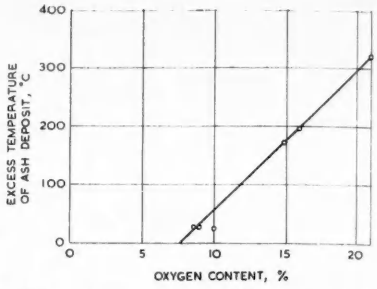


Fig. 3. **Action of oxygen content of furnace atmosphere on combustion intensity in large ash deposits.**
Temperature of furnace atmosphere, 300° C; self-ignition temperature of ash deposit, 400° C.

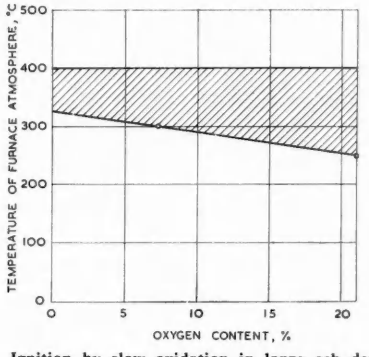


Fig. 4. **Ignition by slow oxidation in large ash deposits, with varying oxygen content of the furnace atmosphere.**
Self-ignition temperature of deposit, 400° C. The shaded area shows the region of ignition by slow oxidation.

Conclusions.

The risk of self-ignition in air preheaters is mainly due to unburned soot and oil in the deposit and to the volume of the deposit itself; it depends only to a slight extent on the composition of the oil ash in other respects. It is therefore important, especially during the initial period, that atomisation and combustion of the oil should be satisfactory. A thin, oil-containing deposit ignited spontaneously at 245° C, while a larger and more compact deposit of the same type ignited at 160° C. To minimise the risk of fire in air preheaters, deposition must be prevented as far as possible by regular soot-blowing and inspection.

The damper in a steam boiler is never entirely gas-tight, and the amount of air escaping generally provides ample oxygen for intense combustion. Yet, air velocity is never sufficient to provide effective cooling, so that too early closing of the damper entails a risk of fire in the air preheater.

To avoid damage, it is important to detect such a fire at its inception. It may therefore be advisable to instal some kind of temperature indicator, which will either operate a warning signal or will automatically inject carbon dioxide to reduce the oxygen content of the air preheater, thereby lowering combustion intensity.

Hobbing at High Cutting Speeds

By H. A. Koop. (From *Werkstattstechnik und Maschinenbau*, Vol. 44, No. 4, April 1954, pp. 155-157, 11 illustrations).

Attempts have been made to increase the economic efficiency of the hobbing of gears and splined shafts by the use of higher cutting speeds and feeds. American investigations* have been described and apparently show that, within certain limits, the rate of wear of the hob may decrease with increasing cutting speed and feed (Figs. 1 and 2). The following German investigations, however, do not bear out this conclusion.

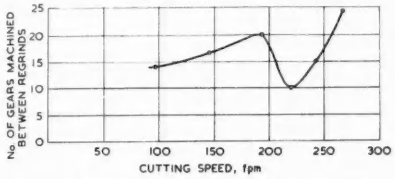


Fig. 1. **Wear of a gear hob as a function of cutting speed, from American tests.**

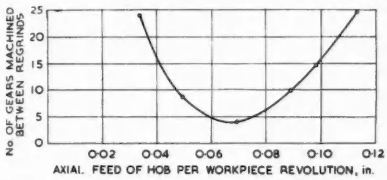


Fig. 2. **Wear of a gear hob as a function of feed, from American tests.**
Cutting speed = 275 sfm.

Influence of cutting speed on tool life.

Machine: "Pfauter RS 9" hobber, with horizontal workpiece and vertical tool axis; motor running at double the normal speed; Vee-belt drive.

Workpiece: Splined shaft of Cr-Mn steel, 40 tons U.T.S.; 2·68 in. o.d., 2·44 in. root diameter; 8 splines, 0·47 in. in width and 10·63 in. in length.

Tool: Spline hob of high-speed steel, 65 Rockwell C; 3·15 in. diameter, 1·26 in. bore; 12 axial grooves for chip relief.

Process: Radial-axial down-milling; axial feed of tool, 0·063 in. per revolution of workpiece; Shell cutting oil. The cutter was ground before each test series and used until the most highly stressed cutting edge showed traces of wear 0·008 in. in depth (Fig. 3).

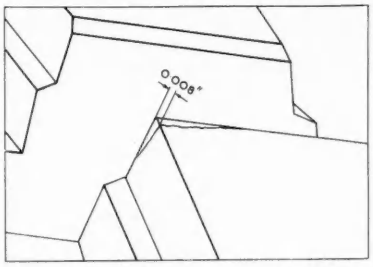


Fig. 3. **Typical traces of wear at the cutting edge of a spline hob.**

In contrast with the American observations, a steady decrease in tool life with increasing cutting speed was noticed; this decrease took place rapidly at first, then more slowly, as shown in Fig. 4. The life was halved

*Rapp, "*Machinery*", U.S.A., December 1952.

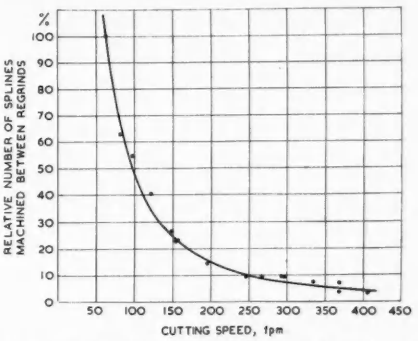


Fig. 4. **Wear of a spline bob as a function of cutting, from German tests.**
Axial feed of hob = $\frac{1}{16}$ in. per revolution of workpiece.

when the speed increased from 100 to 150 surface feet per minute. Similar results in principle must be expected with other materials for workpiece and tool, or with other coolants, although the curve itself may change to a steeper or shallower form. Numerous tests with various types of hobs and machines and with different materials have confirmed this expectation. The only exception which may occur is when the cutting speed corresponds to a resonant frequency of the machine. On the other hand, the quality of the surface improves appreciably with higher speeds; machining cracks are extensive at speeds of 60 sfm and gradually disappear at higher speeds; feed marks are most pronounced at 190 sfm but disappear when speeds rise to 335 sfm. Obviously, different materials will not behave similarly, but the phenomena will be the same in principle.

Influence of feed on tool life.

Machine: "Pfauter P 500" hobber, with vertical axis of workpiece.

Workpiece: Transmission gears of plain carbon case-hardening steel, 42 tons U.T.S.; 36 straight spur teeth with a 20-degree pressure angle, 4 mm module (about 6 D.P.), 0·79 in. in width.

Tool: Spur-gear hob, with inserted cutting teeth of super high-speed steel, 5·51 in. diameter, 1·58 in. bore; 18 axial grooves for chip relief.

Process: Radial-axial down-milling; cutting speed 275 sfm; mineral cutting oil. Each test series was continued until traces of wear, 0·012 in. in depth, were seen.

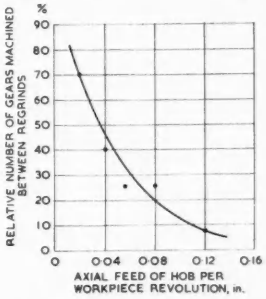


Fig. 5. **Wear of a spur-gear hob as a function of feed, from German tests.**
Cutting speed = 275 sfm.

It was found that the rate of tool wear increases rapidly with increasing feed, at least within the normal range of feeds (between 0·012 and 0·24 in. per workpiece revolution), as shown in Fig. 5. With a feed of 0·12 in. per revolution of workpiece the wear is, for instance, 6 times as great as with a feed of 0·04 in. It is possible that for very small feeds the rate of wear may increase slightly, because the tool then presses and rubs, instead of cutting properly.

From the above tests, it is concluded that hobbing at high cutting speeds offers undeniable advantages insofar as production time and surface quality are concerned. The weak point is the hobbing cutter, which must still be improved considerably for efficiency at high speeds.

U.S.A.

The Use of Aluminium in Pressure Vessels

By J. B. CAMPBELL. (From *Materials and Methods*, Vol. 39, No. 4, April 1954, pp. 97-101, 9 illustrations.)

As there are many structural materials which are stronger and less expensive, aluminium is selected for an unfired pressure vessel only where it offers a significant technical or economic advantage which cannot be matched by another material at less cost. The most common reason for the selection of aluminium is its corrosion resistance. The economic importance of minimising the rate of disintegration of equipment handling corrosive chemicals is obvious. Often, resistance to general external attack by polluted plant atmosphere is important. Even where corrosion rates are too low to destroy equipment rapidly, contamination caused by corrosion products may present a serious problem in quality control. In many pressure-vessel applications, the choice of material narrows down to stainless steel or aluminium. Where product contamination is the most important factor, aluminium offers the particular advantage of colourless corrosion products.

Other advantages of aluminium in pressure vessels are as follows :—

Non-Sparking:—The non-sparking characteristics of aluminium are often considered advantageous in the handling of highly inflammable chemicals.

High Reflectivity:—Aluminium's high reflectivity of radiant heat and light often suggests its use for storage tanks containing volatile chemicals.

High Thermal Conductivity:—Aluminium has much higher thermal conductivity than most structural materials used in unfired pressure vessels. This factor has limited significance in thin-walled heat-transfer applications, but is of some importance in thick-walled vessels.

Light Weight:—Comparison of densities and permissible design stresses shows that aluminium offers significant weight savings over copper and nickel, but relatively small savings compared with bronze, monel, and ferrous alloys. Even small weight savings, however, are sometimes important in transportation, particularly aircraft, where operating profits depend on a favourable payload ratio.

Low-Temperature Properties:—Like the other nonferrous metals, aluminium undergoes no marked change in ductility at low temperatures, and no impact test is required under the ASME Boiler and Pressure-Vessel Code. An impact test is usually required for carbon and low-alloy steels and, in many cases, for stainless steels when service temperatures are expected to be lower than —20° F. The yield strength and ductility of aluminium alloy 3S increase gradually with decreasing temperature, and tensile strength increases markedly below —100° F. Other aluminium alloys behave similarly.

The past few decades have seen a steady growth in the use of aluminium alloys for chemical containers and processing equipment. Only in recent years, however, have aluminium alloys been approved under the ASME Boiler and Pressure-Vessel Code, and, until 1952, 2S, and 3S were the only alloys listed. The 1952 Code lists five additional sheet and plate alloys:—4S, 50S, 52S, 61S, and high-purity (99·6%) BD1S. It also includes specifications for bolting materials, pipe, tube, forgings, bars, rods, and shapes. Approval of 52S represented an increase of 87% in permissible design stress over that of 3S for welded construction.

Now, a new and stronger aluminium alloy has become available for use in unfired pressure vessels. The strongest commercial non-heat-treatable aluminium alloy yet offered, it allows welded design stresses 18% greater than in 52S and 120% greater than in 3S, the alloy hitherto most widely used for aluminium pressure vessels. The new alloy, designated GR40A by the ASTM and A54S commercially, is expected to expand the use of aluminium in unfired pressure vessels, and has the following nominal composition :—

Mn 0·10% max. ; Cu 0·10% max. ; Mg 3·1-3·9% ; Cr 0·15-0·35% ; Zn 0·20% max. ; Ti 0·20% max. ; Fe + Si 0·45% max. ; Be 0·0005% max.

For operating temperatures up to 100° F, the maximum permissible stress in tension for A54S is 7350 psi, for 52S it is 6250, and for 3S only 3350. These values apply to the annealed (0) temper. Higher design stresses, representing various degrees of strain hardening, are approved under the Code. However, they cannot be applied to welded construction, as no more than an annealed temper can be assumed in the weld zone after fabrication. Almost all pressure vessels are now fabricated by welding.

As an example of the increase in wall thickness required when replacing a stronger material by aluminium, Fig. 1 shows the relative wall thicknesses of A54S and type 304 stainless-steel unfired pressure vessels. The curves show that, as pressure increases, the stronger metal gradually increases its advantage over the weaker. Where operating pressures are relatively low and the vessels are fairly large, the ratio is substantially reduced in actual construction, since the minimum thickness of the stronger metal is determined by manufacturing practice.

Like all other aluminium alloys, A54S is limited by the Code to a maximum service temperature of 400° F. As shown in Fig. 2, the permissible design stress for this alloy falls off fairly rapidly for service temperatures above 200° F. In the range from 100 to 300° F, however, the ratio of its maximum permissible design stress to that of stainless steel is higher than at room temperature. The favourable low-temperature properties of aluminium alloys make it possible to use them for applications where temperatures may go as low as —325° F.

The modulus of elasticity of aluminium alloys is only one-third that of ferrous alloys. By conventional design formulae, it can be calculated that the thickness of an aluminium alloy shell must be about 40% greater than that of a ferrous alloy shell to ensure equal rigidity of the wall. Since this figure is well within the increase in thickness required by a consideration of bursting strength, the difference in modulus, despite its magnitude, is not highly significant in pressure-vessel design.

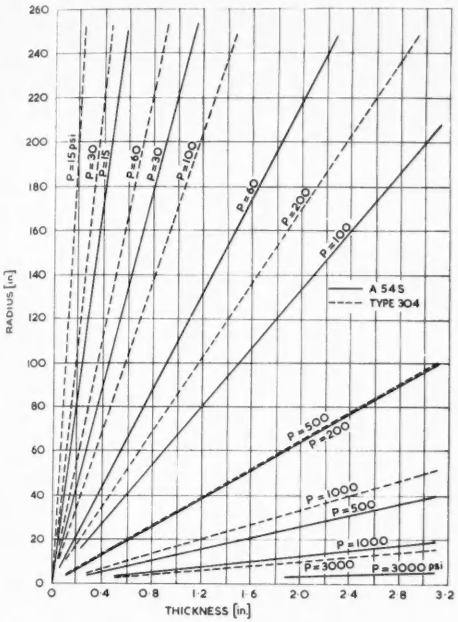


Fig. 1. **Relative wall thickness of A54S and type 304 stainless-steel unfired pressure vessels.**

It is difficult to generalise on costs. One factor is the cost of materials. Aluminium alloy A54S appears to be the least expensive of the corrosion-resistant materials, although stainless steel is only slightly more expensive.

Another factor is cost of fabrication, of which welding cost is an important part. Welding cost increases substantially as metal thickness increases. Assuming an equal number of welds, therefore, the welding cost of ferrous vessels might be significantly lower than that of the thicker aluminium shells. Sometimes, this economic advantage of stainless steel is reduced by the availability of larger plates in aluminium and the consequent need for fewer welds.

FABRICATION.

The formability of A54S is comparable with that of 52S. Shop experience seems to indicate that, except where certain critical forming operations are needed, the new alloy can be formed on equipment developed for 52S and 61S alloys. In general, the equipment found in most steel-tank shops can be used to form aluminium tanks.

Two welding processes—tungsten arc and consumable electrode, each argon-shielded—are recommended for aluminium pressure vessels. The consumable electrode process is often preferred because of the faster welding rate, resulting in less distortion and weld cracking. The distortion problem is particularly critical in aluminium because its thermal coefficient of expansion is double that of steel. On the other hand, the tungsten arc process is usually required for vertical or overhead welds. As a result of considerable development work in the last few years, it is now possible to obtain butt joints of good quality on aluminium plate up to 3 in. in thickness.

Heads, nozzles, and manholes for aluminium tanks can be purchased from many companies supplying comparable steel parts. Bolted connections are preferred to threaded connections, from the standpoint of both service and maintenance. If a threaded connection must be used, and provided corrosive conditions are not too severe, it is usually recommended that a stainless steel threaded insert be used. Aluminium threads will not take the punishment they are likely to get from workmen used to dealing with steel vessels. If aluminium threaded joints are used, the joint compound must be compatible with aluminium.

The use of steel backing rings on flanged nozzles, manholes, and removable heads is recommended, as they permit the use of relatively thin aluminium flanges. By distributing the bolting pressure, such rings simplify the problem of obtaining a tight seal. Steel backing rings should be painted before assembly; where corrosion resistance is important, the steel rings should be first zinc- or cadmium-plated. Forged flanges of 61S-T6 are often used and require no steel backing rings.

Insulation between aluminium and dissimilar metals is a practice which should be observed throughout construction. Tanks are usually insulated from dissimilar supports by several layers of asphalt or coal-tar paint. Additional insulation is provided by a layer of heavy felt between the support and the tank. Faying surfaces should be sealed to keep out moisture.

Support for horizontal tanks should provide contact with the tank wall for at least 120 deg. of the tank circumference. On vertical aluminium tanks with dished heads, tubular legs welded to both head and side wall provide suitable support.

APPLICATIONS.

Aluminium pressure vessels are now being used in a great many different processing, shipping, and storage applications. Equipment includes piping, heat exchangers, steam-jacketed kettles, pumps, stills, condensers, shipping drums, tanks for tank cars, and plant and field storage tanks. Chemicals handled include many foods, beer, 90% hydrogen peroxide, red fuming nitric acid, ammonium nitrate, formaldehyde, synthetic glycerol, phthalic anhydride, acetic acid, acrylonitrile, fatty acids, and crude oils. Aluminium is also used in the manufacture of synthetic resins and textile fibres, to avoid product contamination. Because aluminium is non-toxic,

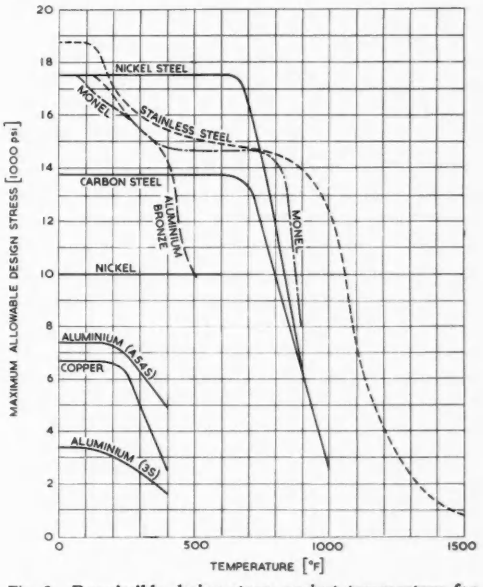


Fig. 2. **Permissible design stress against temperature for aluminium and other metals used in unfired pressure vessels.**

it is used for fermentation equipment used in the production of chemicals by micro-organisms.

In many environments, of course, the use of aluminium would not even be considered. Aluminium alloys are attacked by alkali and alkaline-earth hydroxides, such as sodium and calcium hydroxides, and by certain strong mineral acids, such as hydrochloric acid. Other chemicals which attack aluminium include methyl-chloride and compounds of copper, nickel, mercury, and lead.

SWITZERLAND

Overspeed Safety Governor for High-Speed Turbines

By R. F. MOREILLON. (From *Bulletin Oerlikon*, No. 302, February 1954, pp. 14-16, 5 illustrations.)

A NEW speed-limiting device for high-speed turbines, and in particular for gas turbines, has been developed by the Oerlikon Engineering Works.

This overspeed governor is based on the same principle as that of an earlier slower-speed design for steam turbines but, whereas the latter had to be mounted at the free end of a shaft, the new unit is suitable for high-speed turbines, which in most cases have no free shaft end.

The unit comprises a spring-restrained eccentric mass, which is acted upon by centrifugal force. On reaching a set speed limit (about 10 to 12% above normal running speed), the centrifugal force becomes greater than the restoring force of the spring, so that the mass moves radially over a distance of a few millimetres, thereby causing the operation of a safety valve.

The advantages of this overspeed safety governor may be enumerated as follows :—The unit, which is built in the form of a ring, can be mounted directly on the turbine shaft and, as a result, it does not require transverse drilling of the shaft, with consequent weakening ; the governor can be adjusted and tested as a separate unit ; and it is a simple and sturdy design, suitable for mass production in standard sizes.

Fig. 1 illustrates the main features of this governor. The inner sleeve (1) is keyed to the turbine shaft. On this sleeve are mounted two collars (2) and (3) which, together with a loosely-mounted ring (8), are also parts of the governor casing. An annular eccentric (2′) forms part of collar (2), which can be rotated on inner sleeve (1), so as to adjust the preload of a spring (7), which provides the initial tension.

Collar (3) is keyed to inner sleeve (1) and contains two radial guide grooves (4). Mounted on the eccentric (2′) is another ring (5), guided by a pin (6), which can slide in one of the guide grooves (4) of collar (3). The outer ring (8) has two lugs (9) which support a pin (10).

It is evident that outer ring (8), with lugs (9) and pin (10), forms a mass whose centre of gravity is outside the shaft axis, and which will therefore be displaced by centrifugal forces. The direction of motion of this mass is determined by pin (10) and a guide lug (not shown in Fig. 1), both of which slide in guide grooves (4). The centrifugal force of the mass is opposed by spring (7), which is supported at two diametrically opposite points, i.e., pins (6) and (10). At normal running speeds, this mass is held by spring (7) in its initial position, in which lugs (9) rest on supporting surfaces (11) of the collars (2) and (3).

As soon as the centrifugal force of the eccentric mass becomes greater than the force of spring (7), the mass, sliding in guide grooves (4), moves suddenly in the radial direction over a distance D, and thus actuates the trigger (14) of the safety valve. This releases plunger (15) and spring (16), which permits release of the pressure oil of the governor system, thereby causing immediate stoppage of the turbine.

The device can also be manually operated by pressing knob (17) or by means of remote-control solenoid (18). In both cases, trigger (14) is released by spindle (17′). Furthermore, the governor can be provided with a relay (19), which, when spindle (17′) is displaced, can be made, for instance, to trip the main switch of the generator.

The overspeed limit at which the governor is to operate can easily be set to the required value by adjusting the tension of spring (7), this being achieved by varying the position of the eccentric (2′) or of collar (2) relative to inner sleeve (1). By rotating the collar (2), ring (5) is displaced in a radial direction, and the supporting point of spring (7) on pin (6) is moved further away from (or closer to) the centre of the governor, thus increasing (or reducing) spring tension. The relative position of eccentric (2′) on sleeve (1) is indicated on a graduated scale on the periphery of collar (2). The eccentric is locked in position by a toothed rim and segment (12 and 13).

This new overspeed safety governor gives extremely accurate control, since its response is such that it operates to within 0·2% of the preset value for maximum overspeed. It also operates in the event of any excessive axial displacement of the rotor. As soon as this axial displacement reaches approximately 1 mm, a lip (20) on collar (3) acts on trigger (14) of the safety valve, thus causing shut-down of the turbine.

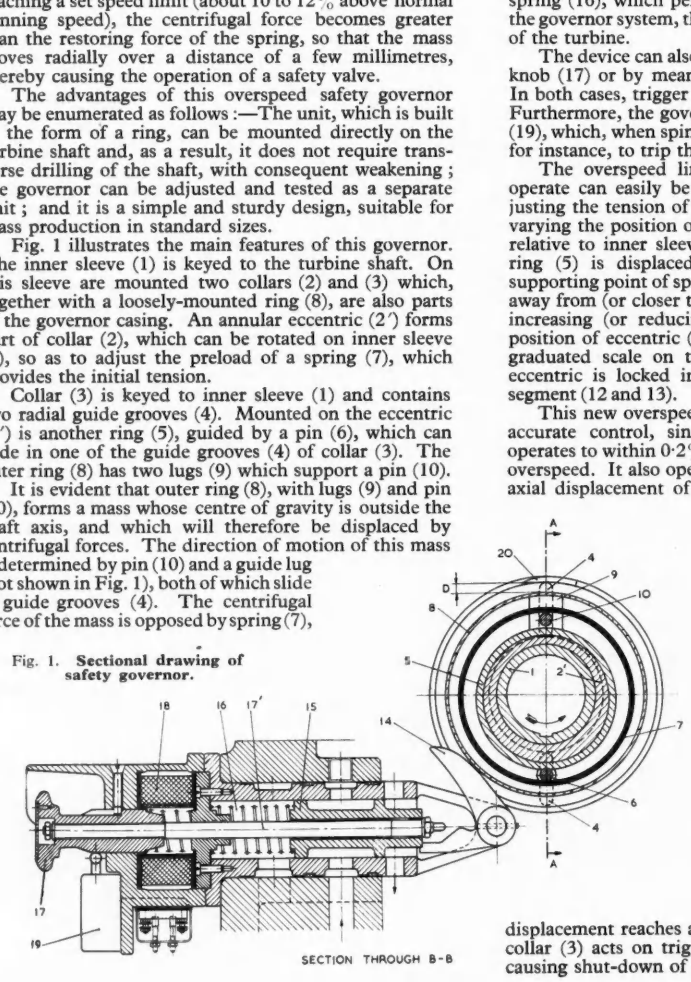


Fig. 1. **Sectional drawing of safety governor.**

New Materials, Processes and Equipment

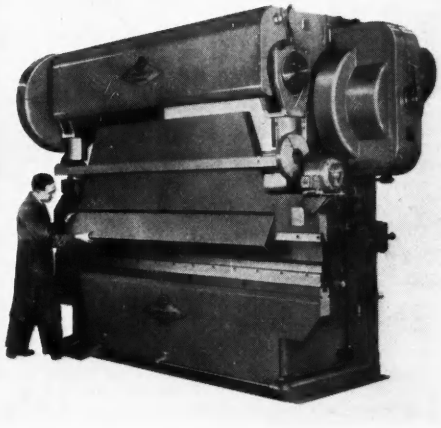
PRODUCTION PRESS BRAKE

The maximum pressure exerted by the new " Besco " production press brake, model 125/70, at nearly the conclusion of its stroke, is 70 tons. This machine, which has been designed and built by F. J. Edwards Limited, of London, N.W.1, makes possible such forming operations as bending and corrugating; beading, seaming, and wiring; punching, including notching, blanking, and piercing; and embossing and pressing. These operations may be executed either individually, progressively, or in multiple, employing single or combination dies and attachments.

The bed and beam extend well beyond the side frames and enable trunk sections to be formed round the overhanging length; the side frames, cut from the solid and open-ended to a depth of 8 in., to accommodate sheets of unlimited width, have a clear space of 97½ in. between them, permitting sheets to be passed straight through the machine. The frame is of heavy welded and bolted rolled-steel plate, constituting a massive unit of the greatest rigidity, and is so designed that no load centres on a welded joint, all loads being transmitted equally through the centre line of the particular member and housing. The bed is solid with the main frame, is deep, and of ample size, to withstand top-capacity work.

The 4½-in. adjustment to the top beam is not manual, but is controlled by an independent motor of 2½ hp, mounted on the right hand pitman. Both pitmans are arranged so that they can be adjusted independently to give equal pressure along the whole length of the beam. The stroke of the top beam is 3 in. and the maximum die space is 15 $\frac{11}{16}$ in. The 8-hp master motor is self-contained and is carried on a platform at the top rear of the right-hand frame, with a V-belt drive to the flywheel and thence through reduction gearing to the main crankshaft. The strokes per minute are 35, the flywheel speed is 530 rpm, and the load speed of the motor is 1440 rpm. Metal guards are supplied and fitted to all exposed drives. The machine stands 9 ft in height and requires a floor space of 11 ft 7 in. × 7 ft 7 in. The net weight is 8 tons 8 cwt.

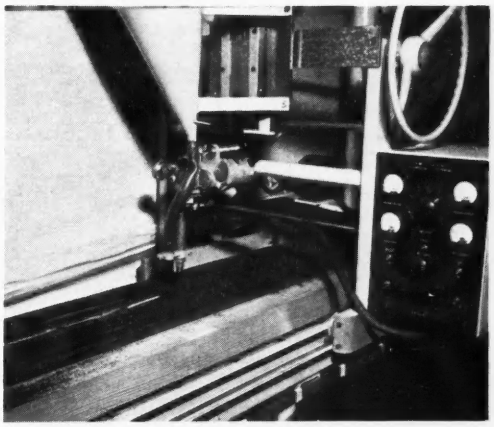
Back gauges can be supplied, reading from zero to 24 in., calibrated in $\frac{1}{64}$ in., screw type, operated by individual handwheel. Each arm is adjustable horizontally left to right in the slotted bed. At the maximum, the total bed length of 126 in. permits a bend to be performed in a 10-ft × 12-gauge mild-steel plate with a ⅞-in. vee die opening.



AUTOMATIC TRACK-RAIL WELDING PROCESS

A new, automatic track-rail welder, called the " Rexarc Automotive Welder," working in any direction in sequence, has recently been developed by the Armor Automotive & Welding Company, of Portland, Oregon.

Setting up a job to be welded by the new process is fast and simple. When welding on crawler-type tractor rails, for example, the entire track—even from the largest tractor—can be placed on the welding bed as a single chain. Thus, the time and expense of separating the track into individual links are eliminated. Lining up other items for flat-bed welding is equally simple, as the welding head is adjustable to a wide range of vertical and horizontal positions, to accommodate a variety of work sizes and shapes. The same versatility is present in positioners for rollers, idlers, and other circular objects, and for specially engineered positioners for specific applications.



After set-up, the " Rexarc " welder progresses the length of the work, depositing metal only where it is required. Welding can be continuous or in sequence, depending upon the requirements of the job. Arrangement for sequence welding is accomplished simply by breaking the circuit on a contact rail with pressure-sensitive tape, thus eliminating the time required for setting up a mechanical device for this purpose. High-frequency starting and stabilisation assure a steady arc at all times during the welding procedure.

The illustration shows the welder arranged for welding on crawler-type tractor rails. The welding breaks at each rail joint and automatically starts at the next link. After starting the arc, the carriage remains stationary until the bead has built up to the desired height and, upon reaching the end of the link, it remains stationary until the crater is filled to the desired level. The angle of the rail is automatically compensated on each succeeding pass. Deposited metal is thus applied to the exact length and shape of the exposed rail link, leaving the joints free. Cutting or grinding after welding is virtually eliminated.

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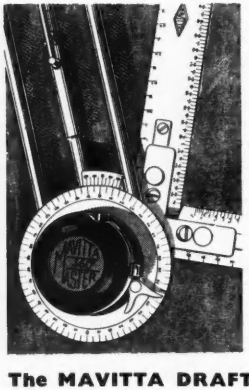

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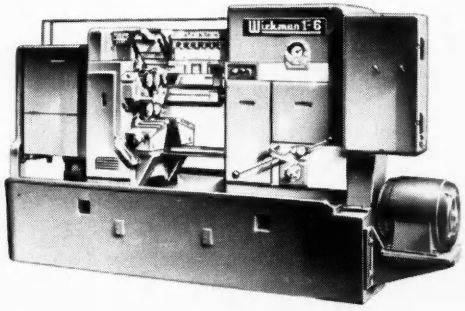

THE NEW WICKMAN 1" 6-SPINDLE AUTOMATIC

This recent addition to the famous Wickman range of Automatics employs three Burgess Micro-Switches. One energises a solenoid which trips the feed when the feed safety clutch disengages as a result of overload. The other two disengage the bar feed clutch when any spindle runs out of bar stock. All three Micro-Switches are our robust metalclad type, reference MK.3BR-MS, provided with conduit entry.

Burgess Micro-Switches provide the reliable and accurate answer to so many automatic switching problems, as Wickman Ltd. have discovered. If you have such a problem, why not consult our engineers? Catalogue No. 50/11 contains details of our standard range.

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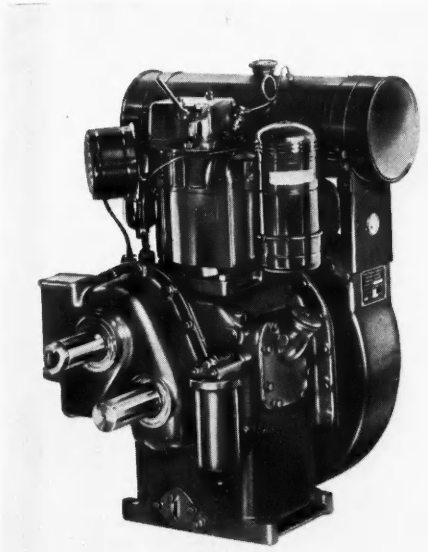
AIR-COOLED DIESEL ENGINES

An entirely new 6-11 hp air-cooled single-cylinder diesel engine, incorporating the experience learned from the operation of their previous 6-8 hp engine, is announced by Armstrong Siddeley Motors Limited, of Coventry.

The new engine (illustrated) not only develops more power than the previous engine, but it is also more compact and weighs less. Other features include accessibility, low maintenance costs, and low fuel consumption.



Also announced is a new twin-cylinder diesel engine, which has been re-rated to cover the range from 14 to 22 hp. 60% of the parts of the new single-cylinder engine are interchangeable with those of the twin-cylinder engine—a point of considerable importance to users of both types.

Bore and stroke for both engines are 4·25 in.; compression ratio is 15 : 1; the speed range is between 1000 and 1800 rpm, engine speed being controlled by a centrifugal bobweight-type governor. Capacities are respectively 60·3 and 120·6 cu in.

A full range of accessories is available, including an industrial clutch, clutch and 2 : 1 reduction gear, centrifugal clutch, acoustic silencers, and special air cleaners. Provision is made for electric starting.

CONTINUOUS MILLING MACHINE

A modified version of their model 2VR continuous milling machine is announced by Adcock & Shipley Ltd., of Leicester. This particular machine was intended for straddle-milling an aluminium component for a motor-car manufacturer.

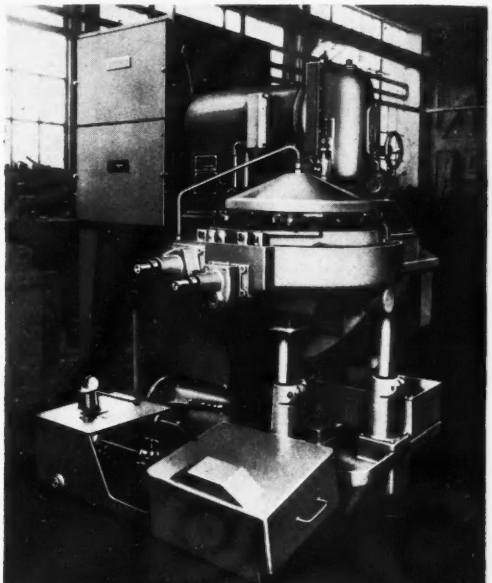
The advantage of this method of milling is that the components are loaded and unloaded whilst they are being milled, so that there is no loss of time due to loading and unloading; furthermore, by careful jigging, idle traversing time is reduced to a minimum.

The standard machine consists of a conventional column with a sliding head, and a 26-in. diameter tee-slotted rotary table mounted on the knee, with adjustment provided both longitudinally and vertically. The sliding head has a vertical adjustment of 3½ in., and is fitted with a worm and worm-wheel adjustment, permitting very accurate settings to be made.

The rotary table on the standard machine is fitted with 8 tee-slots, onto which the user can fasten his fixture, and is driven by a ½-hp feed motor, 9 different rates of feed being available. On the special machine, the rotary table and the jig are combined, and longitudinal adjustment only is provided for the withdrawal of the cutter from the work, the sliding head providing sufficient vertical adjustment for the setting of the cutters relative to the work. Substantial locks are provided to all adjustments, and on the standard machine an additional knee-steady is provided, whilst on the special machine illustrated, two knee-steadies were supplied, to ensure even greater rigidity.

To meet the user's special requirements in the case of this straddle-milling operation, the standard table was replaced by a special unit incorporating hydraulically operated fixtures, a separate, motor-driven, hydraulic pump unit being mounted near the machine. The oil supply was fed under pressure to the centre of the fixture and passed through radial valves to the radially disposed cylinders operating the clamping mechanism of the fixtures. One cylinder was used for each pair of fixtures. As the table rotated, pressure was applied, first to one end of the cylinder to clamp the component, and then after it had passed the cutter, oil was fed to the other side of the cylinder to release the component. In the loading and unloading position the component was lightly held by springs, to retain it until the full clamping pressure was applied hydraulically.

The question of swarf was given most careful consideration, the fixture being so designed as to have a conically shaped top of sufficient steepness to prevent swarf lying on it; rubber mouldings were used around the moving parts of the fixtures, to avoid any small particles of swarf entering them.

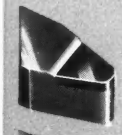


On this particular machine, a single-speed motor was used to give 5 hp at 1460 rpm. This speed was reduced by a gearbox to a spindle speed of 658 rpm, being the equivalent of 1000 fpm for the 6-in. diameter cutters. Special high-rake side and face cutters were employed, giving a very clean finish, even at the high feed rates possible with the material. The customer's requirements of one component every 15 seconds were easily achieved.

Wimet – Britain's first carbide tools

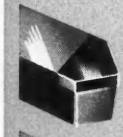
Way back in 1927 Wickman introduced carbide tools to this country. Since that time their use has spread so widely among the metal-working industries that to-day the name 'Wimet' has become synonymous with carbide tools and the higher productivity they bring. And with good reason; they cut faster, last longer, maintain accuracy and reduce tooling costs.

Here's today's range of standard turning tools available from stock



STRAIGHT ROUND NOSE TURNING TOOLS
For light-duty turning work, boring, chamfering, or profile turning.

CRANKED ROUND NOSE TURNING TOOLS
For light cuts, plain turning and facing.



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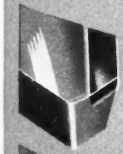

HEAVY-DUTY TURNING AND FACING TOOLS
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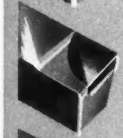
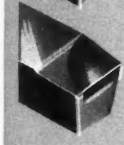


BAR TURNING TOOLS
For plain turning to square shoulders, recessing and counter boring.



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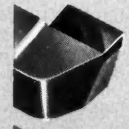
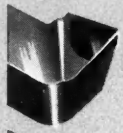
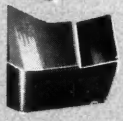


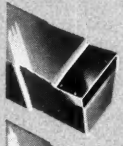
CRANKED KNIFE TOOLS
For broad facing cuts or similar operations.



CRANKED TURNING TOOLS
For light-duty turning and facing, boring and turning to square shoulders, etc.



CRANKED TURNING AND FACING TOOLS
For heavy-duty plain turning, facing, chamfering, boring, etc.



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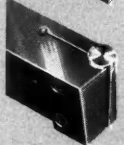

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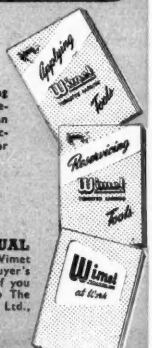

THE WIMET MANUAL contains full details of all Wimet Standard Tools—it's the buyer's guide for carbide tools. If you use carbide tools write to The Publicity Dept., Wickman Ltd., for a copy.

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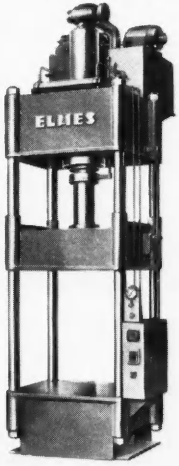
HYDRAULIC PRESS FOR REINFORCED PLASTICS MOULDING

A complete range of newly designed hydraulic presses, specifically built for fibre-glass moulding, is announced by American Steel Foundries, Elmes Engineering Division, of Cincinnati, Ohio. These presses are made in standard capacities ranging from 50 to 300 tons, but presses of higher tonnage can be designed and built to suit individual requirements.

In the particular Elmes press illustrated, the main ram capacity is 100 tons and the stripping capacity 30 tons. The press has an operating pressure of 2460 psi, a 36-in. stroke, and accommodates dies up to 48 in. from left to right, and up to 36 in. from front to back. Operation is fully pushbutton-controlled. The press advances at a speed of 400 ipm and, upon reaching a predetermined adjustable position, it automatically slows down to the desired pressing speed, which is adjustable downward from 16 in. to practically zero inches per minute.

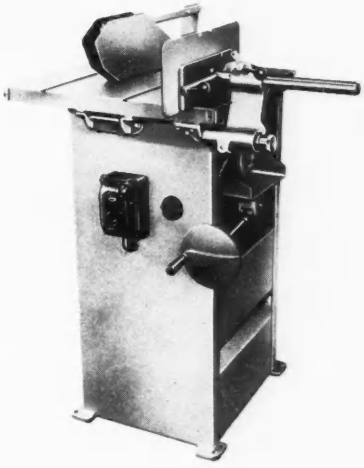


An adjustable timer is also provided, which can be pre-set for any length of cure cycle desired. When the cure time has run out, the press will automatically open at a predetermined break-away speed, adjustable to practically zero inches per minute. After it has moved away from the work a predetermined distance, the press returns to the up-stop position at a rate of 400 ipm. The up-stop position can be adjusted by changing the position of the corresponding limit switch. Thus, it is not necessary to utilise the full 36 in. of stroke on the return cycle. Any portion of this stroke can be used, by adjusting the return-limit switch.

RISE-AND-FALL SAW BENCH

Introduced to complete their range of $2\frac{3}{4}$ and $4\frac{1}{8}$-in. saw benches, the new 10-in. saw manufactured by Startrite Engineering Company Ltd., of Gillingham, Kent, will cut timber up to $3\frac{1}{8}$ in. in thickness, and is arranged to carry out many operations, in addition to straight, cross, and bevel sawing.

A special guide and protecting device can be readily bolted to the machine table for grooving and shaping. This unit includes fully adjustable vertical and horizontal guide pieces mounted on spring-steel pressure plates. The guides support the stock as closely as possible to the moulding cutter and ensure complete protection to the operator. A new, well designed moulding block, with safety fixing for knives, can be supplied as an optional extra. Sets of two interchangeable knives are available



in nine different patterns, for rebating, chamfering, fluting, joint moulding, etc. A $\frac{1}{2}$-in. capacity wobble saw, 10-in. sanding disc, " Carboflex " grinding disc, and special blades for cutting metals and plastics are also supplied as extra equipment.

The basic machine design comprises a rigid cast-iron saw table, 20 × 23 in., with mitre grooves on either side of the blade. The precision-ground saw spindle is mounted in dust-sealed ball bearings and the rise-and-fall mechanism is operated through a conveniently placed handwheel and screw. A heavy-duty graduated canting fence accommodates work 14 in. to the right of the saw. Additional capacity can be obtained by lowering the fence trunnion bracket and operating the fence face-plate in an extended position. The fence mechanism is fitted with a subsidiary fine-screw adjustment for accurate setting, while an entirely new parallel-action safety guard covers the blade at any depth of cut.

WEIGHT INDICATOR FOR ROPE SYSTEMS

A dead weight indicator, primarily intended for use on portable oil-derrick rigs, has been introduced by The B. & A. Engineering Co. Ltd., of London, S.W.1.

This instrument, designated Model 4/40, measures the total load in a $\frac{1}{2}$- or $\frac{5}{8}$-in. diameter four-part rope system by a deflection in the rope imposed by accurately placed rollers and, in addition to use on drilling rigs, can be freely adapted for equipment or plant where it is necessary to measure the force in ropes. In place of the standard dial on the unit, a transmitter can be fitted, which activates a remote electrical load indicator, and which can be mounted in any desired position. The dial can be calibrated in pounds or tons, as required.

This weight-indicator is a compact unit of 21 in. in height, 7 in. in width, and 9 in. in depth, the weight complete being 35 lb. The load is transmitted through freely rotating rollers to a hydraulic cell unit, which is completed enclosed and sealed. The dial, 6 in. in diameter, shows the total load on the hook of a four-part rope system, up to a 25,000-lb working range, but with an overload margin up to 40,000 lb.

The indicator can be readily adapted for heavier loads and different rope systems. Installation is rapid and simple, by means of a rope clamp fixed to the dead-line rope, and adjustment is provided for both $\frac{1}{2}$-in. and $\frac{5}{8}$-in. diameter wire ropes. Some advantages of the instrument are that the method of transmitting the load

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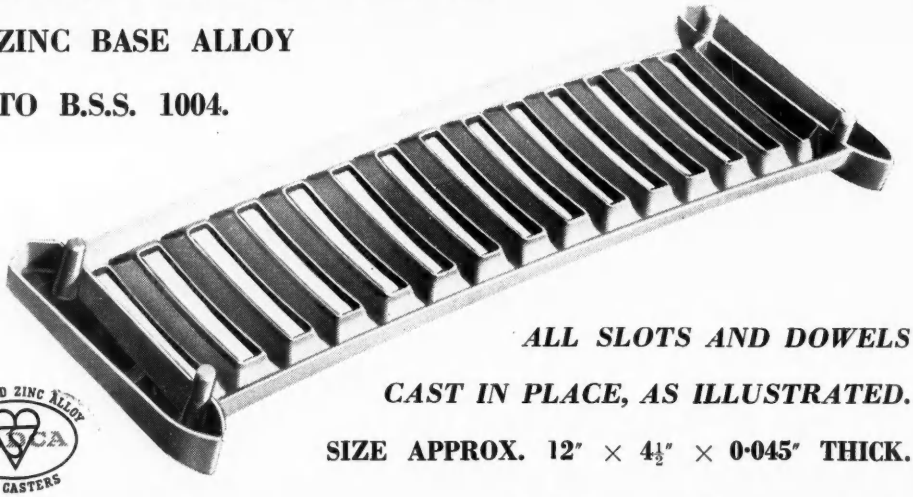

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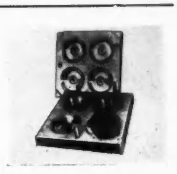

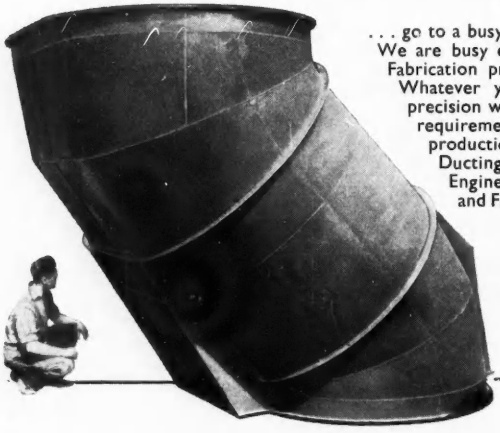

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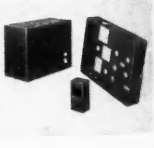

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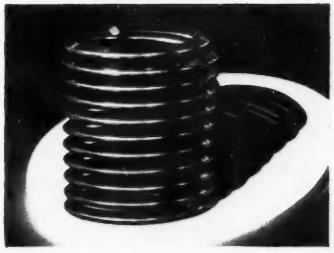
ensures permanent accuracy, unaffected by rope deformation caused by overtightening of the rope clamp, and that no frictional losses are incurred on load-bearing parts. The gauge incorporates a shock and vibration damper, and a dial light is also fitted.

This indicator is intended to compete with American-designed and produced units now being used in quantity in Sterling areas and is believed to be the first British production of its type.

WIRE THREAD INSERTS

A full range of " Heli-Coil " wire thread inserts, for use in the automotive, electrical-equipment, and metal-working industries, is announced by Armstrong Patents Co. Ltd., of Beverley, Yorks. Intended primarily for installation as initial equipment, they are also used to salvage threads damaged during manufacture, and to repair threads damaged through prolonged use.



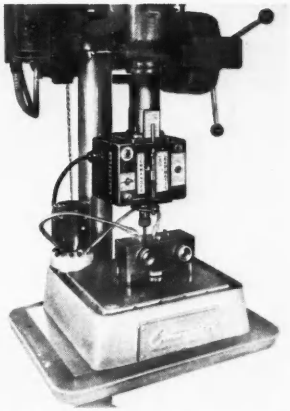
These stainless-steel inserts, when used in iron, steel, aluminium, magnesium, wood, and plastics, provide threads with higher loading strengths and greater resistance to wear than normal threads in the same material. They can be used to provide any class of fit, depending on the tolerances to which the user elects to hold the " Heli-Coil " tapped hole, and are supplied in lengths of 1, 1½, 2, 2½, and 3 times the nominal diameter of the screw. For special applications, non-standard lengths and sizes can also be supplied.

AUTOMATIC LEAD-SCREW TAPPING ATTACHMENT

A new, electrically controlled, automatic high-production lead-screw tapping attachment, with a range of from zero to ¾ in., and which fits any drill press, has recently been introduced by the Commander Manufacturing Co., of Chicago, Illinois.

Known as the Commander " Lead-Matic " tapper, the new unit is designed to handle all types of production tapping—precision or otherwise. Simple electrical controls, located on the face of the unit, permit quick, easy selection of the proper tapping action, either jog or cycle, best suited to the particular tapping operation.

The device is provided with a precision-ground lead screw which pilots the tap into the work. Perfect thread lead and concentricity are assured by the lead screw, while the drill press merely provides rotation. Consequently, any inaccuracies of the drill press are not reflected in the performance of this attachment, which incorporates the lead screw, lead nut, and the entire tapping mechanism in a single compact, lightweight, and rugged unit.

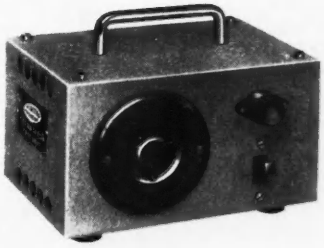


The spring-clutch drive mechanism provides automatic reversal of the tap and no drill-press motor reversal is required, making the entire tapping cycle faster and easier to accomplish.

EARTH-CONDUCTOR EFFICIENCY TESTER

A safety-factor device for rapidly testing the earth-conductor efficiency of portable electric tools is announced by Electro Methods Ltd., of Stevenage, Herts.

Known as the " Terra-Tertia " Test Unit, type 121, the instrument is connected to an a.c. mains supply, 220-250 V, 50 cps, and the tool to be tested is plugged into a 15-A, three-pin socket on the front panel; with the body of the tool pressed against the instrument's handle, the panel-switch is then depressed. In this arrangement, a high current at low voltage flows through the earth conductor and associate plug which, if satisfactory, withstands the current flow and lights the " Pass " lamp on the front panel. If the earthing system is faulty, the lamp will not light. Consequently, should the lamp itself fail, it is impossible for the tool, faulty or otherwise, to be passed as safe.



A frequent danger in portable electric tools is the partial fracture of the earth conductor, owing to negligence or wear and tear. In such cases the instrument's high test current at low voltage is sufficient to burn out completely the remaining strands of the partially fractured earth wire, thereby anticipating the failure during work.

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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

CRYSTALLOGRAPHY

Lattice Imperfections and Plastic Deformation in Metals.

By H. G. VAN BUEREN. (From *Philips Technical Review, Holland*, Vol. 15, No. 8-9, February-March, 1954, pp. 246-257, and No. 10, April 1954, pp. 286-295, 24 illustrations.)

MICROSCOPIC examination of the surface of metals which have been polished and subsequently deformed usually reveals a pattern of fine, more or less straight lines. The more the metal is deformed, the more clearly these so-called slip lines become visible and the greater is their number. The orientation of these lines appears almost invariably to correspond to the planes in the crystal in which the atoms are most closely packed. This relationship is found to be the most marked in metals with the closest-packed crystal structure. In metals having body-centred cubic lattices which are not packed as closely as possible, the slip lines are somewhat irregular, but the relationship between the slip lines and the crystal planes still remains.

The observed slip over a distance of many times the atomic spacing in a single slip plane, and the low value of the observed critical shear stress can be explained by introducing the idea of special kinds of lattice defects known as dislocations. These are produced in large numbers during the actual process of deformation by so-called Frank-Read sources (the emission of dislocation loops). In principle, no limit has been set for the number of dislocations which can emanate from a source, although, in practice, slip distances greater than about 1000 times the atomic spacing on a single slip plane are seldom observed; actually, most slip lines represent a displacement of not more than some tens to some hundreds of times the atomic spacing. According to various workers in this field, this limitation in the number of dislocation loops produced should be attributed to the stress set up by the emitted dislocations at the originating source itself; this stress is opposed to the applied stress, causing the deformation and, provided it is large enough, may check the activity of the source.

In this article, the theoretical necessity for the existence of lattice imperfections in crystals, such as vacancies, interstitial atoms, and dislocations, is clarified in the light of a number of phenomena related to the plastic deformation of metals, e.g., the occurrence of slip lines, work hardening, and variations in the electrical conductivity. The article discusses the more important characteristics of dislocations, and deals successively with the geometrical aspects of various kinds of dislocation, their behaviour under shear stresses in the crystal, as illustrated by means of a model, and the movement of dislocations, taking into account the difference between conservative and non-conservative movements. The formation of lattice defects of different kinds as the outcome of interaction between existing defects is examined.

The plastic deformation of metals by the mechanism of slip is discussed with reference to microscopic observations. Points dealt with include the various kinds of slip lines visible on the surface of deformed metals, the work-hardening resulting from the stress fields round the dislocations, and deformation bands which constitute experimental evidence of the blocking of dislocation movements. Polygonisation and recovery are briefly discussed, as well as some phenomena related to lattice defects in alloys, i.e., ageing phenomena. In conclusion, some comments are made on the variation in resistivity due to plastic deformation, and its possible theoretical explanation.

ELECTRICAL INSTRUMENTS

Thermocouple-Type Ammeters for Use at Very High Frequencies.

By O. G. MCANINGH. (From *Electrical Engineering, U.S.A.*, Vol. 73, No. 5, May 1954, pp. 431-435, 10 illustrations.)

THE measurement of currents at the higher frequencies is complicated by the ever-magnified inductances and capacitances associated with the measuring equipment. On direct currents, permanent-magnet moving-coil instruments are used extensively, and here the main consideration is the series resistance of such instruments. Instruments for lower frequency alternating currents generally make use of an electrodynamic or some form of moving-iron measuring system. Here again, the series resistance of the instrument is important but, in addition, the series inductance of the necessary coils becomes a factor. As the frequency is increased, the effects of the inductance increase, and in the middle audio-frequencies, these effects become formidable.

This article reviews problems encountered in the measurement of current at the higher frequencies, and discusses the performance of ammeters tested in the very-high-frequency range. It also presents the theory, construction, and performance of an experimental, wide-frequency-range ammeter having superior characteristics in the very-high-frequency band.

In this instrument, which is of the low-impedance thermocouple type, a short concentric terminal arrangement replaces the usual side-by-side terminal studs. This configuration reduces the internal circuit length of the instrument and assists in reducing impedance; in addition, it serves to shield the d.c. instrument parts from the high-frequency current field, and to prevent the series induction of high-frequency voltages in parts of the d.c. instrument circuit. The heating element is made from a thin, flat ribbon, rather than from the usual round wire, to reduce skin-effect error as much as possible. To reduce the series impedance of the instrument still more, the inductance of the heater is lowered by folding the flat-strip heater back on itself, forming a hairpin-like structure, the two halves of which are separated and insulated by a thin sheet of mica.

The thermocouple junction itself is welded to the mid-point of the heater strip near the fold, and the cold junctions are welded to two small pins, which are thermally intimate with, but electrically insulated from, the plate connecting the inner and outer terminals. To prevent any possible series induction in the d.c. instrument loop circuit, the two leads from the thermocouple cold junctions to the instrument armature are twisted together along most of their length. One of the most significant improvements in the instrument is the impedance reduction from terminal to terminal throughout the heater. This design reduces skin effect,

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During the autumn of 1950, a municipal authority asked Esso for technical assistance in the running of some diesel driven pumping units at one of their water pumping stations. High oil consumption and excessively smoky exhausts were causing concern.

One of the engines (a large vertical 2-stroke) was opened for inspection. Most of the compression rings were stuck, scraper rings were very dirty, oil drain holes were choked, the exhaust ports were fouled, and there was general sludging. Cylinder wear was of the order of .004″/.005″ after 1,000 hours running. A change from the straight, non-additive type of lubricating oil then in use was recommended.

About this time a new Esso detergent-type oil had been perfected and exceptionally good results were being obtained in various critical engines. In addition to its powerful detergent and anti-oxidant additives the new oil contained a special wear-reducing additive, and it was finally decided to test it in the troublesome engines at the pumping station. The new oil was called Diesel Lubricant T.S.D. 337A.

Early results were encouraging. The oil consumption diminished considerably, and subsequent engine inspections showed that sludging troubles had disappeared, together with loss of efficiency due to ring sticking and port fouling.

Periodic testing of the used lubricating oil showed that T.S.D. 337A remained in good condition after 3,000 hours in service, whereas the oil formerly in use was in poor condition after only 1,000 hours. Moreover, the engine was in excellent mechanical order when stripped after the longer interval. The use of the new oil was soon extended to the other pumping sets, with equally satisfactory results.

Routine dimensional checks have shown a marked reduction in the rate of cylinder liner wear. This has fallen from approximately .004″/.005″ per 1,000 hours with the straight oil to between nil and .002″ per 3,000 hours with T.S.D. 337A. Thus the rate of wear has been reduced by nearly 90%.

We agree that this is an exceptional case, but every engine that has been changed over to T.S.D. 337A has shown a marked degree of improvement in cleanliness and wear.

Your own lubrication problems can in all probability be solved with substantial benefits by the use of Esso Industrial Lubricants. There is a complete range of special products for all industrial purposes and we shall be pleased to offer you free advice without obligation. May we arrange for one of our Industrial Representatives to call and discuss the matter with you ?

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reduces extraneous heating of the thermocouple wires, and decreases resonance effects, by eliminating some of the loop circuits and by decreasing the inductance in others.

FATIGUE OF METALS

Fatigue as a Factor in Pressure-Vessel Design.

By T. J. DOLAN. (From *The Welding Journal, U.S.A.*, Vol. 33, No. 6, June 1954, pp. 265s-275s, 13 illustrations.)

THIS article discusses the factors influencing the fatigue strength of metal members from the viewpoint of their applicability to the design of pressure vessels. Stress range and number of cycles of loading are of primary importance in determining whether fatigue failure may develop. The types of blemishes, notches, or recesses in the contour determine the severity of the peak stresses from which progressive fractures will initiate, if the loading is repeated a sufficient number of times.

Consideration is given to environmental conditions such as depressing the temperature, thereby increasing the fatigue strength, whereas raising the temperature to high levels induces creep and lowers fatigue properties. Erosion or corrosion are serious in producing microscopic pits, serving as severe stress raisers which produce fatigue damage, and should be avoided wherever possible. Periodic rest periods of no load have no harmful effects on the fatigue resistance of a vessel. The presence of sound fusion-welded joints of high quality has no deleterious effects, but can lead to marked reductions in fatigue strength, if improperly designed or if the weld contains undercuts, porosity, slag, or poor fusion.

In general, thick-walled vessels subjected to extremely high pressures are likely to be more susceptible to initiation of fatigue cracks than low-pressure thin-walled containers, but all vessels which are intended for long life and to be subjected to a large number of pressure fluctuations in service should be designed to ensure adequate fatigue resistance by eliminating excessive stress-raisers and by carefully controlling fabrication and operating procedures. Fatigue data are statistical in nature, being influenced by chance effects in sampling, manufacture, and testing; thus, exact design procedures are not available and the designer must be satisfied with attaining a fairly high probability that the member will not develop fatigue failure within the normal service life.

It is fortunate that small decreases in the peak stresses are accompanied by large increases in fatigue life, but the reverse is also true. Consequently, the elimination of severe stress raisers is the principal difficulty and is the most effective method of ensuring safety against progressive fracture; if peak stresses are significantly reduced, the question of exact fatigue becomes more of academic than of real interest.

FLUID MECHANICS

Ignition and Combustion in a Laminar Mixing Zone.

By F. E. MARBLE and T. C. ADAMSON. (From *Jet Propulsion, U.S.A.*, Vol. 24, No. 2, March-April 1954, pp. 85-94, 8 illustrations.)

THE analytic investigation of essentially two- or three-dimensional laminar combustion processes presents some mathematical difficulties. There are, however, several examples of two-dimensional flame propagation which involve transverse velocities that are small in comparison with that in the principal direction of flow. Such examples occur in the problem of flame quenching by a cool surface, flame stabilisation on a heated flat plate, combustion in laminar mixing zones, etc. In these cases the problem may be simplified by employing what is known in fluid mechanics as the boundary-layer approximation, since it was applied first by Prandtl in his treatment of the viscous flow over a flat plate. Physically, it consists of recognising that, if the transverse velocity is small, the variations of flow properties along the direction of main flow are small in comparison with those in a direction normal to the main flow. The analytic description of the problem simplifies accordingly.

The present analysis considers the ignition and combustion in the laminar mixing zone between two parallel moving gas streams. One stream consists of a cool combustible mixture, while the second consists of hot combustion products. The two streams come into contact at a given point and a laminar mixing process follows, in which the velocity distribution is modified by viscosity, and the temperature and composition distributions by conduction, diffusion, and chemical reaction. The decomposition of the combustible stream is assumed to follow first-order reaction kinetics, with temperature dependence according to the Arrhenius law.

For a given initial velocity, composition, and temperature distribution, the questions to be answered are: (1) Does the combustible material ignite? (2) How far downstream of the initial contact point does the flame appear and what is the detailed process of development? Since the hot stream is of infinite extent, it is found that ignition always takes place at some point in the stream. However, when the temperature of the hot stream drops below a certain value, the distance required for ignition increases so enormously that essentially it does not occur in a physical apparatus of finite dimension. The complete development of the laminar flame front is computed, using an approximation similar to the integral technique introduced by von Karman into boundary-layer theory.

IRON AND STEEL

Deboronisation of Steels.

By J. C. SHYNE and E. R. MORGAN. (From *Metal Progress, U.S.A.*, Vol. 65, No. 6, June 1954, pp. 88-90, 4 illustrations.)

BORON, as an additive to alloy steels for the purpose of increasing hardenability, is unique in several respects. Added in minute quantities, it can cause a remarkable increase in hardenability, as compared with similar amounts of other alloying elements. The small amounts required per ton of steel and the abundance of boron make it an almost unlimited resource as a hardenability agent for low-alloy steels.

Unfortunately, the use of boron in steel is accompanied by several difficulties. Some of the anomalous behaviour which has been attributed to boron steels may have been caused by deboronisation. Boron, like carbon, is removed from steel at austenitising temperatures by a process of oxidation at exposed surfaces, combined with diffusion to those surfaces. Boron differs from carbon in that the oxide of boron is solid and remains on the surface, while carbon has gaseous oxides. While this has been known for several years, the practical implications of deboronisation in connection with the standard end-quench hardenability test have so far been ignored.

This article describes tests made to determine the effect of deboronisation on the end-quench hardenability test. The experimental results and computed deboronisation curves suggest that the standard end-quench procedure should be modified for boron steels. The problem of deboronisation during the austenitising of end-quench specimens can be avoided simply by making the hardness survey on flats prepared at sufficient depths below the surface.

In view of the demonstrated deboronisation effects, much of the published data on boron steels must be regarded in a new light. The possibility that deboronisation may have occurred during end-quench tests cannot

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be ignored. Experiments which have involved long periods or high temperatures should be especially liable to this type of error. Similarly, results of such experiments as those in which end-quench bars are carburised are subject to deboronisation errors, because deboronisation seems to occur even in a carburising atmosphere. It is proposed that a modification of the standard end-quench test procedure should be adopted for boron steels, in order to eliminate possible errors resulting from deboronisation.

MACHINE-SHOP PRACTICE

Graphical Method of Determining Machine-Tool Motor and Drive Requirements.

By O.-H. BLAUM. (From *Werkstatt und Betrieb, Germany*, Vol. 87, No. 5, May 1954, pp. 209-213, 8 illustrations.)

THE calculation of gear ratios and motor capacities for machine tools is normally a lengthy process, which often has to be repeated many times before the final values are obtained. The many factors involved, such as cutting speed and force, spindle speed, feed rate, gear ratios and gear efficiency, motor capacity, speed, torque, and efficiency, tend to complicate the calculations. The effect of a change of any one of these factors is difficult to evaluate. These calculations concern not only the designer but also the production engineer who wishes to use existing machines to full capacity or to improve their performance by providing them with more powerful drives.

This article describes a graphical method which has been evolved and which eliminates these tedious calculations by providing a rapid means of obtaining the required data. Two separate charts are used, both of which utilise logarithmic scales. One of these covers all the machine factors, while the other deals with motor characteristics. The two charts can be used together by superimposing them on one another and lining them by means of a " capacity " line shown on both charts. Using these charts in practice is relatively simple, bearing in mind the number of variables involved. The following example indicates the type of application for which they can be employed with great advantage :—

The gear ratios and motor capacity, at a given efficiency, are required for a lathe intended for roughing and finishing of steel components, the cutting speed, cutting force, and work diameter range being given. Constant cutting speed is required for facing operations. Furthermore, the machine is to be used for machining non-ferrous alloys, and it is necessary to know what maximum cutting power is available at a given high cutting speed. All this information is obtainable from the two charts.

The charts can be used for direct-current motor drives, as well as for pole-changing a.c. drives and for infinitely variable speed drives.

MAINTENANCE ENGINEERING

Adaptation of Engineered Maintenance to Plants of Moderate Size.

By C. N. LANIER, JR. and J. D. QUINN. (From *Mechanical Engineering, U.S.A.*, Vol. 76, No. 6, June 1954, pp. 500-502.)

MAINTENANCE is becoming increasingly significant as more and more labour-saving devices are developed, and is beginning to command the attention of industrial firms, both large and small. All types of maintenance work offer opportunities for reducing work load. Work-load reduction is a phase of maintenance operation which is not being given sufficient attention in many plants. The tendency is to accept maintenance as required work and to make it more effective, rather than to consider the basic reasons for its being necessary. The correct approach would appear to be to adopt the attitude that there should be no maintenance and then to require justification for all work which it is found necessary to carry out.

Engineered maintenance involves a systematic study of maintenance requirements and the adoption of efficient practices and procedures. It suggests that maintenance should be considered with the same care and serious purpose as plant construction, plant operation, and product marketing. It undertakes to lower maintenance costs, but not at the expense of excessive breakdowns and lost production. It recognises the value of preventive measures, but insists on knowing how often preventive operations are necessary. Even more so, it is concerned with overall reduction in the work load in the long run, and refuses to accept present conditions as inevitable.

With increased automation, considerable attention is being directed to engineered maintenance in the larger industrial plants. Certain of these techniques are adaptable to maintenance activities in plants of moderate size. This paper, therefore, considers methods for increasing productive capacity by reducing the maintenance-work load in plants with maintenance forces of from 10 to 50 men.

POWDER METALLURGY

Infiltration of Metal-Powder Parts.

By J. L. EVERHART. (From *Materials & Methods, U.S.A.*, Vol. 39, No. 4, April 1954, pp. 88-90, 7 illustrations.)

THE mechanical properties of a metal-powder compact are closely related to relative density, because pores act as internal notches. By the elimination of porosity, considerable improvement in strength and ductility can usually be obtained. Thus, in the formation of iron-copper compacts, pressures of about 25 tsi can be used to form the iron skeleton. This skeleton, after infiltration with copper, has been found to be at least as strong as a medium-carbon steel compact pressed at 60 tsi, sintered, re-pressed, and re-sintered.

For the successful infiltration of porous compacts with metals, certain conditions must be met, if optimum results are to be obtained. The melting points of the two metals should be as far apart as possible; limited solubility is advantageous, and intermediate phases should be limited, as they can hinder the progress of infiltration; in the infiltration operation, the temperature should be maintained as close to the melting point of the infiltrate as possible, to prevent washing; the time should be short to minimise alloying; and oxide skins must be avoided.

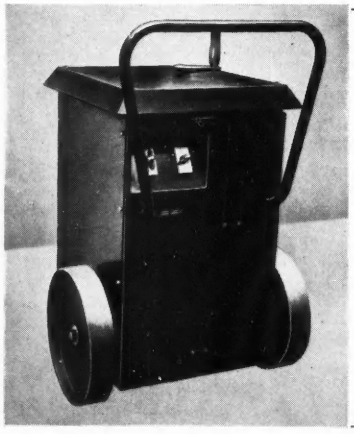
The nature and degree of improvement obtained by infiltration depend to a certain extent on the characteristics of the skeleton and the infiltrant. There are several possible relations between these materials. Thus, if no solubility and no wetting occur, the product has a duplex structure, and the properties are dependent upon the relative quantities of the two materials. If wetting occurs, but there is no mutual solubility, the structure is again duplex and the properties are not changed greatly. If wetting and solubility exist, the product is capable of developing good mechanical properties which, in systems having limited solubility, can often be improved by precipitation-hardening heat treatments.

One of the outstanding applications for iron impregnated with copper is in stator blades for jet-engine compressors. Well over 10,000,000 of these blades have been produced. Among the advantages claimed for the infiltrated blades are elimination of heavy forging equipment, extended die life, lower scrap loss, and the use of less highly skilled labour. The composite blades can be nickel- or chromium-plated, soft-soldered, or brazed.

Stainless steels have been used as the skeleton material, with copper and various copper alloys as impregnants. The infiltration of a stainless steel with silver has been mentioned, and similar work has been

SOME EXAMPLES FROM THE COMPREHENSIVE RANGE OF

WELDING EQUIPMENT *by* PHILIPS



PHILIPS TYPE ES 3566

350 AMP. AIR COOLED

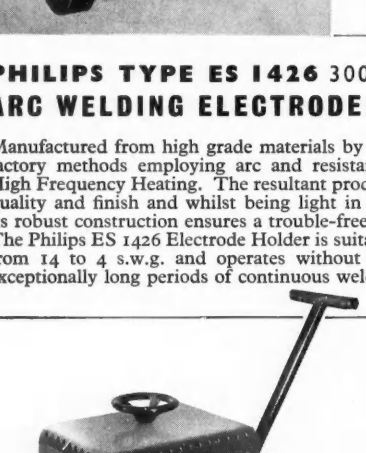
WELDING TRANSFORMER

A fully portable A.C. Welding Plant for medium and heavy fabrication. The transformer is suitable for connection to single phase or across 2 phases of a 3-phase 50 cycle supply. It is housed in a robust sheet steel cabinet — a built-in fan guarantees adequate cooling under all conditions.
Output : 60 — 350 Amps. Current continuously variable.
Arc Voltage : 24 — 34.5 Volt.
O/C Voltage : 75 — 80 Volt.
Primary Tappings : 190, 200, 220, 250, 380, 400, 440 and 500 Volts.
Total Weight : $3\frac{1}{4}$ cwt.

PHILIPS TYPE ES 1426 300 AMP.

ARC WELDING ELECTRODE HOLDER

Manufactured from high grade materials by the most modern factory methods employing arc and resistance welding, and High Frequency Heating. The resultant product is of excellent quality and finish and whilst being light in weight ($20\frac{1}{2}$-ozs.) its robust construction ensures a trouble-free life.
The Philips ES 1426 Electrode Holder is suitable for electrodes from 14 to 4 s.w.g. and operates without overheating over exceptionally long periods of continuous welding.



PHILIPS TYPE 1381/1

FULLY PORTABLE

WELDING TRANSFORMER

A fully portable A.C. Welding Plant for medium fabrications, sheet-metal welding, maintenance work and garage and agricultural repairs. Low initial outlay and low running costs are special features of this unit. Input links easily adjusted to permit connections to different supply voltages — 200, 225, 400, 440 volts; single phase 50 cycles, or across 2 phases of a three-phase system.
The welding current control is continuous over the entire range of 15 to 200 amps. Two current ranges are available :—
Low range — 15 to 100 amps. O/C voltage 80/100 volts.
High range — 30 to 200 amps. O/C voltage 40/50 volts.
Approximate dimensions — 1 ft. $6\frac{1}{2}$ in. x 1 ft. 5 in. x 1 ft. $11\frac{1}{2}$ in.
Approximate weight — 200 lb.

For full details of complete range, write for Philips Arc Welding Catalogue PD.3515

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INDUSTRIAL GROUP, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

INDUSTRIAL X-RAY EQUIPMENT · ELECTRONIC APPARATUS · LAMPS AND LIGHTING EQUIPMENT · ARC AND RESISTANCE WELDING PLANT AND ELECTRODES · MAGNETIC FILTERS · BATTERY CHARGERS AND RECTIFIERS · H.F. HEATING GENERATORS · RADIO AND TELEVISION RECEIVERS (W238A)

carried out on a stainless steel-copper combination. In this development, copper was infiltrated into austenitic stainless steel skeletons. By sintering the compact before infiltration, strengths of 100,000 psi and elongations of 5 to 6% were obtained. Since these materials are soluble to some extent, the strength values are considerably better than those obtained with the stainless steel-silver combination.

Among other developments is the infiltration of refractory carbides with various high-temperature alloys, to develop new high-temperature materials. Porous titanium-carbide compacts infiltrated with high temperature nickel or cobalt-base alloys have shown excellent strength, combined with notable ductility and impact resistance at temperatures up to 1800° F. They have also exhibited satisfactory resistance to oxidation up to this temperature. Impregnated titanium-carbide parts of this type have possessed transverse-rupture strengths up to 300,000 psi at room temperature and up to 150,000 psi at 1800° F. At room temperature, similar parts have shown impact strengths of 10 ft-lb, as determined on an unnotched Izod bar, which compares with 3 to 3·5 ft-lb for cemented titanium carbide of the same composition.

In 100-hr stress-rupture tests, infiltrated titanium-carbide parts have shown strengths of 38,000 psi at 1600° F and 16,000 psi at 1800° F. These contrast with 21,000 psi at 1600° F and 11,300 psi at 1800° F for the best cast super-alloy now in use in jet-engine components.

STRENGTH OF MATERIALS

General Method of Calculating Mechanical and Thermal Stresses in Discs of any Shape.

By R. A. STRUB. (From *Bulletin Technique de la Suisse Romande, Switzerland*, Vol. 80, No. 8, April 17, 1954, pp. 97-106, 19 illustrations.)

THE oldest method of calculating mechanical and thermal stresses in discs, due to Grammel, consisted in subdividing the disc into a number of elements of constant thickness; the step-by-step evaluation was correspondingly somewhat lengthy. Subsequently, hyperbolic profile elements were used as a basis, but these were not suitable for discs with divergent sections. Later, the solution for stress distributions in convergent conical profiles was published by Martin and Honegger. The procedure was simplified by Keller and Salzmann, but it was still applicable only to mechanical stresses.

The general method developed by the author takes account of both mechanical and thermal stresses. The stresses in the rotor, which may have a convergent or divergent profile, are determined from differential equations, taking account of centrifugal force and temperature. The results of the integrations are presented graphically, in fifteen charts, with radial and tangential stresses for disc elements of constant thickness, with a linear temperature distribution. Axial stresses are disregarded.

In all cases where the principle of superposition is valid, the charts can be used to determine the stress contributions due to each individual action. For instance, for a disc shrunk on to a shaft and rotating under conditions giving a non-linear temperature field, the procedure is to determine firstly the stresses due to radial pressure at the central hole, secondly those due to a radial load on the disc periphery (representing the action of the blades), thirdly the stresses due to rotation, and finally the temperature stresses. Outlines of calculations are given in the form of tables for the superimposed stresses. Account is also taken of variations in the modulus of elasticity and the thermal expansion coefficient. Numerical examples include a hydraulic-brake rotor of the two-row bucket type, for which the mechanical stresses are determined, and a turbine disc of a turbo-jet engine, for which the stresses due to mechanical loading and temperature are evaluated.

WELDING

Working Conditions of Operators of Inert-Gas-Shielded Metal-Arc Welding Equipment.

By L. SILVERMAN and H. GILBERT. (From *The Welding Journal, U.S.A.*, Vol. 33, No. 5, May 1954, pp. 218s-229s, 4 illustrations.)

THE development of new welding techniques and procedures requires a re-investigation of the possible exposure of operators to new or different health hazards. This particular study is primarily directed at conditions in the breathing zone of the newly developed inert-gas-shielded metal-arc welding process with consumable electrode, to determine the concentrations and significance of the various gases and particulate matter produced, and to compare them with various welding metals and with conditions found in conventional electrode welding.

On the basis of this study, recommendations and conclusions are as follows :—

(1) It is apparent that inert-gas-shielded metal-arc welding does not create any unusual health hazards. Fume and gas concentrations are not markedly different from those of conventional electrode welding.

(2) Ozone concentrations are greatest near the arc and exceed permissible limits outside the helmet in the working zone, if no control is applied. Ozone concentrations inside the helmet are below recommended limits owing to dilution and ozone decomposition.

(3) Inert-gas-shielded metal-arc welding produces higher ozone concentrations on aluminium than on stainless steel, but no difference could be noted between argon- and helium-shield gases.

(4) Stainless-steel inert-gas-shielded metal-arc welding does not produce significant hexavalent chromium concentrations. Iron fume should be controlled within specified limits for elimination of visibility loss, etc. (15 mg/m^3).

(5) The fume hazard from silicon-alloy welding of aluminium is proportional to the amount of silicon present. Silica-fume concentrations exceed permissible limits with 5% silicon-aluminium alloys, unless local ventilation is used. As a tentative limit, in the light of present knowledge on the effects of mixed alumina and silica exposures, it is recommended that total fume concentrations be maintained below 15 mg/m^3 for aluminium alloys where silicon is only an impurity. The total fume concentration when silicon is present should be such that the silica concentration does not exceed 0·1 mg/m^3.

(6) Oxides of nitrogen concentrations are below permissible limits, even in the absence of ventilation. The inert-gas shield, reactions with fumes, and ozone prevent abnormal air concentrations in the working zone.

(7) When it is desirable to control fumes and gases from arc welding, the use of lateral exhaust ventilation is the most efficient. Care must be taken in its use, however, to avoid disturbing the inert shield. Fume concentrations with the inert-gas-shielded metal-arc welding process appear to be independent of the type of shielding gas.

(8) There is no basic reason for believing that the general specifications for arc-welders' filter glass, ordinarily used in coated-electrode welding, do not give adequate protection against long-wave infrared, although a more highly absorbent infrared glass combination is recommended at present, until an adequate quantitative study is made. The recommended composition for satisfactory control is given in this article.

(9) Operators sensitive to gaseous products of welding, such as ozone, should use local exhaust, supplemented by air-supplied helmets, if necessary.

(10) In terms of deposited material, inert-gas-shielded metal-arc welding produces less fume per unit weight of electrode wire used, when compared with coated-electrode arc welding.

Inserting an X-ray tube into its oil-filled, ray-protective and shock-proof casing.

PROGRESS IN ELECTRONICS

In 1895, Röntgen startled the world with the discovery of an entirely new form of radiation. Whilst engaged in the study of electric discharges in vacua, he detected an invisible ray which had the remarkable property of penetrating human tissue to present a shadow picture of bone formation on a photographic plate.

The radiations, which became known as X-rays, were at first used primarily to produce medical radiographs. In those early days such radiographs required exposure times of about fifteen minutes; but today, with the aid of modern X-ray tubes, diagnostic radiographs of extremely high definition are obtainable in less than 1/800th second.

A significant contribution by Mullard to this outstanding progress is the rotating anode diagnostic tube. Providing a high X-ray intensity from an optically sharp point source, these tubes produce radiographs of high quality and definition in very short exposure times.

The latest Mullard achievement in this field is the development of a rotating anode tube of such high power and short exposure time that it enables motion-picture studies to be made of internal bodily functions. This tube is already proving of immense value in the diagnosis of diseases of the heart and circulatory system, as well as of the stomach and the brain.

The scope of X-ray science is continually expanding. In addition to medical radiography, X-rays are being applied to the treatment of cancer, the study of the structure of matter, the non-destructive examination of materials, and the detection of foreign particles in foods. The Mullard organisation, with its extensive research and manufacturing facilities, is contributing to further progress by the production of X-ray tubes of the highest quality.

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NEWS OF THE MONTH

PERSONAL

Mr. H. C. Adams, M.C., M.A., M.I.C.E., has been appointed assistant chief engineer at the headquarters of the Ministry of Transport and Civil Aviation, in succession to **Mr. C. S. Chettoe, B.Sc.(Eng.), M.I.C.E.,** who is retiring in September next.

Mr. W. Kenneth G. Allen, joint managing director of W. H. Allen Sons & Co. Ltd., has been elected to the Board of Whessoe Ltd.

Mr. C. K. Andrews has been appointed technical manager of Mitchell, Colman & Co. Ltd., Radcliffe, Lancashire.

Sir Hugh Beaver, M.I.C.E., M.I.Chem.E., has been appointed chairman of the Advisory Council for Scientific and Industrial Research, in succession to **Professor Sir Ian Heilbron, D.S.O., D.Sc., F.R.S.,** who is retiring next September.

Mr. M. N. Boyde has been appointed sales manager of Polygram Casting Co. Ltd., Power Road, London, W.4.

Mr. R. E. Buell has been appointed controller of the technical division of the Regent Oil Co. Ltd., 117 Park Street, London, W.1.

Mr. T. W. Bushell has been appointed principal surveyor for metals of Lloyd's Register of Shipping, in succession to **Mr. W. E. J. Lewis, B.Sc.,** who retired after completion of 28 years' service.

Sir Harold Roxbee Cox, Ph.D., D.I.C., B.Sc., M.I.Mech.E., F.R.Ae.S., who has been chief scientist to the Ministry of Fuel and Power since 1948, has resigned from his position, in order to accept an appointment in industry.

Mr. W. Cushworth has been appointed a director of Buckley & Taylor Ltd., Castle Iron Works, Oldham, Lancs.

Sir Bernard Docker has been elected chairman of Carbodies Ltd., Coventry. **Mr. R. E. Smith** has been appointed managing director of the company.

Mr. J. L. Girling has been appointed by the President of the Board of Trade Comptroller-General of Patents, Trade Marks and Designs.

Mr. G. H. Hargreaves, M.C., B.Sc., M.I.C.E., has been promoted to deputy chief engineer (civil engineering) at the Ministry of Transport and Civil Aviation, in succession to **Mr. J. F. A. Baker, M.I.C.E., M.I.Mun.E., A.M.Inst.T.,** who has been appointed chief engineer (highways). **Mr. J. D. W. Jeffery, T.D., A.M.I.C.E.,** has been appointed assistant chief engineer at the Ministry.

Mr. F. R. Livock, B.Sc.(Eng.), M.I.E.E., A.M.I.Mech.E., has been appointed sales director of Metal Industries (Electrical Division) Ltd., Victoria Station House, London, S.W.1, parent company of Brookhirst Switchgear Ltd., Cantie Switches Ltd. and Igranic Electric Co. Ltd.

Mr. Ian Arthur Marriott, who was commercial director of the Brush Group and later managing director of W. G. Bagnall Ltd., Stafford, and the Parsons Engineering Co. Ltd., Southampton, has been elected to the Board of Wellworthy Ltd., Lymington, Hants.

Mr. J. C. Morris, B.Sc., A.M.I.C.E., F.R.San.I., borough engineer and surveyor of Willesden, has been elected chairman of the council of the Royal Sanitary Institute, 90 Buckingham Palace Road, London, S.W.1.

Mr. R. Ivor Slater has been elected a director of Moorwoods Ltd., Harleston Street, Sheffield 4.

Mr. G. C. Walton has been appointed sales manager of McKechnie Brothers Ltd., Rotton Park Street, Birmingham.

Air Commodore Michael Watson, C.B., C.B.E., has been appointed head of the newly formed Radar Systems Division of Decca Radar Ltd., 1/3 Brixton Road, London, S.W.9. He will be assisted by **Mr. S. J. Kyte.**

Mr. Arthur Whiston has been appointed sales manager of Stuart Davis Ltd., Much Park Street, Coventry. **Mr. W. K. North** has been appointed London manager, in succession to Mr. Whiston.

Dr. S. Whitehead, director of the British Electrical and Allied Industries Research Association, 5 Wadsworth Road, Perivale, Greenford, Middlesex, has been elected chairman of the Committee of Directors of Research Associations.

BUSINESS NOTES

The Magnesium Advisory Committee, formed in 1952, has now been reconstituted as The Magnesium Industry Council. The purpose of the Council is to promote the production and use of magnesium and its alloys, and its services are available to Industry and to the Ministries responsible for the Defence Programme. Mr. E. Player, of Birmid Industries Ltd. has been elected chairman of the Council. The secretaries are Wenham Brothers & Co., 21 Bennet's Hill, Birmingham 2.

Statistics of the Iron and Steel Industry of the United Kingdom for 1953. The British Iron and Steel Federation has just published the Statistical Year Book which gives comprehensive statistics on every aspect of the U.K. steel industry's operations during 1953, with comparative figures for earlier years. Copies may be obtained from the Information Office, Steel House, Tothill Street, London, S.W.1. Price: 7/6.

A Bibliography of Colour Television has been issued by The Television Society, 164 Shaftesbury Avenue, London, W.C.2. Copies of the 16-page brochure can be obtained from the Society's office at 2/- post free.

Permali Ltd., Bristol Road, Gloucester, announce that the address of their London office has been changed to Windsor House, 46 Victoria Street, London, S.W.1. Tel. No. ABBey 6494.

The branch office of the B.S.A. Tools Group in Toronto, Canada, at present known as Burton, Griffiths & Co. Ltd., will operate as from August 1st, 1954, under the name of B.S.A. Tools Ltd. The office will continue under the management of **Mr. E. J. Stokes** at 19 Melinda Street, Toronto 1, Ont., Canada. Tel. No. Empire 6-0984.

The Hughes Tool Company of Houston, Texas, has been allocated one of the factories built by the Government of Northern Ireland at Castleragh, near Belfast. The factory covers an area of over 86,000 sq. ft. The new project is expected to save the U.K. economy some 1,500,000 dollars annually in the purchase of American equipment by British interests. Production of the factory is likely to be concentrated on the manufacture of standard-size drilling bits, for sale mainly in the soft currency area.

Sylvania-Thorn Colour Laboratories Ltd., a new company, has been formed in agreement between Thorn Electrical Industries Ltd. and Sylvania Electric Products Inc., for the manufacture in Great Britain of colour television cathode-ray tubes.

The Yale and Towne Manufacturing Co. Ltd., Willenhall, Staffs., announce the formation of two divisions, the British Lock and Hardware Division and the British Materials Handling Division. **Mr. H. Gilbert Ramsell** has been appointed general manager of both divisions.

THE RECIPROCATING TOGGLE THEN ACTUATES THE PLUNGER IMPELLER

It's as clear as that, except for endless modifications and sleepless nights sorting out production difficulties. The spring part can be left to Lewis, of course. That has become a habit in the last thirty-five years.

Estab. since 1919. A.I.D. approved.

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We don't ask you to take to the Bush...

. . . we want you to take to the GLACIER STANDARD BUSH, and the whole commonsense idea of Standard Sizes.

Suppose you're stubborn . . . Suppose you ignore our advice, demand a bush specially produced, in meagre quantities, to some bastard size of your own which entails special drawings, patterns, toolings and so on . . . Very well ! For the sake, perhaps, of a trifling difference in one dimension (and your own naughty pride) you pay more and wait longer—and kick yourself thereafter.

Suppose you follow our advice . . . Why, then you discover that our Standard Range covers 191 variations in perfect series, graduating in length, nominal bore, and housing size. You take your pick from five grooving designs. You order from stock for immediate delivery, finished and ready in Glacier lead bronze, with an allowance in the bore for final sizing. You waste no time and you pay less.

Whether it's bronze bushes, wrapped bushes

or bronze bars, that's the logic behind . . .

GLACIER Standard Sizes

REGD. TRADE MARK

THE GLACIER METAL COMPANY LIMITED, ALPERTON, WEMBLEY, MIDDLESEX

Mackay Industrial Equipment Ltd., Faggs Road, Feltham, Middlesex, have been appointed sole distributors of the Pescara-Muntz air compressors manufactured by Alan Muntz & Co. Ltd.

The Junior Institution of Engineers has moved to its new premises at 14 Rochester Row, London, S.W.1. Tel. No. VICtoria 0786.

R. B. Pullin & Co. Ltd., Phoenix Works, Great West Road, Brentford, have been granted by the Ministry of Supply Design Approval for gyroscopic instruments under the D.Inst.R.D. Design Approval Scheme.

This approval follows the recent acceptance by the Ministry of Pullin's latest gyro instrument, the Mk. IIA Turn and Slip Indicator.

The General Electric Company Ltd. of England is to supply microwave radio relay equipment to carry television programmes in Canada between London and Windsor, Ontario. The order has been obtained by the Canadian General Electric Co. Ltd., the main contractor for the scheme, jointly from Canadian National Telegraphs and Canadian Pacific Telegraphs.

The link, which will employ similar equipment to that used on the Swiss Eurovision link supplied by the G.E.C., will incorporate four relay stations. It will carry 525-line pictures in black and white, or in colour. The installation is to be carried out in three stages, i.e., a one-way link, a second link in parallel which is reversible, and the conversion of the first link into a reversible system.

The Timken Roller Bearing Company has announced that it will build an atomic bomb-proof vault at its New Philadelphia plant. This vault will withstand pressures and heat from an atomic bomb hit outside of a half-mile radius of its location. It is believed that such a vault is necessary to safeguard valuable microfilm records. It is another step in the Timken Company's continuing effort to protect employees' jobs and help assure continued delivery of Timken Company products in the event of an atomic bomb attack.

An example of the important microfilm records to be stored in the vault is the company's 375,000 engineering drawings, the number of which is growing at the rate of 19,000 a year.

The base of the vault will be eleven feet underground and it will be 27 feet square and sixteen feet high. Reinforced concrete will be used in the construction of the vault. The walls will be 15 inches thick and the ceiling, 18 inches thick. A heat pump system will control temperature and humidity at all times. In the event of failure of the system it is estimated that the microfilm will be protected for a minimum of thirty days.

M. & C. Switchgear Ltd., Kirkintilloch, Glasgow, announce that plans have now been approved for a further extension to their Kelvinside Works. The extension will provide an additional 25,000 sq. ft. for new bays for an enlarged machine shop, a light fabrication department and increased area for the assembly departments. £50,000 will be spent on this latest extension and new equipment.

Fibreglass Limited, St. Helens, Lancs. have been successful in securing the order for ten million square feet of pipe wrap in face of strong U.K. and overseas competition. This will be used as anti-corrosion protection of the 350-mile, 16-in. steel pipeline project recently announced by the Government of Pakistan.

D. Andersons & Sons Limited, Stretford, Manchester, have also obtained the order for three million square feet of "Thermoglas," a coal tar saturant outer wrap having a Fibreglass base.

This pipe line—one of the larger projects of its type—will tap the natural methane gas reserves at Sui and feed Karachi industrial undertakings in the first case, and later, will be available for domestic supplies. The basic cost of the project, which has been partly financed by the World Bank, is approximately £9,000,000 and in the final stages a further £1,000,000 will be spent.

The initial load is estimated to be 37 million cubic feet per day for cement and power plants which will be increased to 54 million cubic feet per day after four years operation and finally to 118 million cubic feet per day by 1964.

The whole of the 41,606 tons of 16-in. steel piping will be buried and the laying involves two carriage crossings of 4,725 feet and 3,000 feet (the pipe line crosses the Indus between Hyderabad and Kotri) and numerous canal crossings.

The anti-corrosive protective tissue will be field wrapped on the pipes by a line travelling machine.

The new Hoover Factory which has recently been opened at Meadowbank, on the Parramatta River, Sydney, Australia, occupies fifty-four thousand sq. ft., thirty-five thousand of which will be devoted to production, the remainder being used for administrative purposes. **Mr. P. Attwood,** director of Hoover Ltd., has been responsible for the progress of this new development. Working with him has been **Mr. J. Halifax,** formerly superintendent of Hoover's High Wycombe factory. He is now works manager of the new factory, which will function as Hoover Industries Pty. Ltd. The commercial manager is **Mr. P. C. Raphael,** formerly purchasing manager of Hoover (Electric Motors) Ltd., Cambuslang, Scotland.

Hoover (Australia) Pty. Ltd., the associated company dealing with sales and administration, will also move to the new building. The management are **Mr. J. S. Drysdale,** managing director; **Mr. P. C. Boon,** director and sales manager; **Mr. H. Roberts,** secretary; and **Mr. J. C. Canton,** technical manager.

CENTENARY OF THE BIRTH OF THE HON. SIR CHARLES A. PARSONS, O.M., K.C.B., F.R.S. (London, 13th June, 1854)

Sir Charles Parsons was the greatest power engineer of his day and achieved an international reputation, for the steam turbine is used on every continent and has practically displaced the steam engine for generating power, both on land and sea.

This centenary is being commemorated at the Science Museum, South Kensington, for about three months by a special display in the East Hall. Sir Charles Parson's original 7½ kW high-speed steam turbo-generator of 1884 is exhibited by the side of a scale-model, one sixteenth full-size, of a modern Parsons 50,000 kW steam turbo-alternator. As both exhibits occupy the same space, the vast development in power production over half a century is strikingly shown. Photographs show other important developments in mechanical, electrical and marine engineering and in the optical industry, due to his pioneer researches and inventions.

The attention of visitors is also drawn to numerous other examples of the work of Sir Charles Parsons, exhibited in various galleries of the Museum.

He died on 11th February, 1931, in Jamaica, whilst on a cruise, in his 77th year.

Hours of opening: Weekdays, 10 a.m. to 6 p.m.; Sundays, 2.30 to 6 p.m. Admission Free.

DEVELOPMENT OF GUIDED MISSILES

The talks in Washington between the United States Secretary of Defence, Mr. Charles Wilson, and the British Minister of Supply, Mr. Duncan Sandys, have been concluded.

Particular attention was paid to problems relating to the development of guided missiles, and arrangements were considered with the object of securing more active co-operation in this field. This should enable both countries to make the most productive use of their available scientific and technical resources and should help to speed up the development and introduction of guided missiles for use in the common defence.

In addition to Mr. Wilson and Mr. Sandys those taking part in the discussions included, on the United States side, Mr. D. A. Quarles and Mr. H. Struve Hensel (Assistant Secretaries of Defence), Mr. John D. Slezak (Under Secretary of the Army), General H. McK. Roper (U.S. Army), Admiral R. A. Ostsie and Admiral John H. Sides (U.S. Navy), Mr. James H. Douglas (Under Secretary of the Air Force), Mr. Trevor Gardner (Special Assistant U.S. Air Force) and General H. B. Thatcher (U.S. Air Force); and on the British side, Sir Roger Makins (British Ambassador), Sir Steuart Mitchell (Controller of Guided Weapons), Dr. O. H. Wansbrough-Jones (Chief Scientist of the Ministry of Supply), Sir Richard Powell (Deputy Secretary of the Ministry of Defence), Mr. S. Scott-Hall (Head of the British Technical Mission in Washington), and Admiral Hughes-Hallett, General Prior-Palmer and Air Commodore Grundy (of the British Staff Mission in Washington).

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Prior to these talks, Mr. Duncan Sandys made an extensive tour of experimental establishments concerned with the development of guided missiles in different parts of the United States.

DEVELOPMENTS IN IRAQ

Mohhamed Zaki Abdul Kareem, director of Information of the Ministry of Development, Baghdad, has sent us an article on the progress Iraq has accomplished during the past 30 years and the multitude of projects planned by the Ministry of Development.

The four internationally owned oil companies operating in Iraq have undertaken to raise oil output from 6 m. tons in 1950 to 30 m. tons a year by 1955. The Iraqi Government's revenue from this source alone for 1951-1955 amounts to £214 m. 70 per cent. of these revenues will be spent to finance developments in the country.

Investments on dams and irrigation, transport and industrial plant will be complemented by increased expenditure on agriculture, health, education, etc.

The Development Board has employed many consulting engineers of international reputation to conduct surveys of the country's resources. They have prepared, together with Iraqi engineers and technicians, the designs and specifications for a multitude of projects.

For the first six years' programme the Board estimated to spend £53 m. on flood control, irrigation and drainage schemes.

There are ample resources for industrial development, including an abundance of oil and gas, a broad range of minerals and cheap manpower. The Board has allocated £31·5 m. for industrial development. The design and erection of a bitumen refinery for more than £1 m. has been entrusted to the Lummus Company, of London. Industrial projects contemplated include two cement factories, a cotton mill, a sugar factory, the utilization of natural gas, electric power stations, etc.

£26·77 m. has been allocated for road and bridge construction and £18 m. for buildings, including schools and hospitals.

More than £1 m. has been allocated to supporting Iraqi students of engineering and technical sciences studying abroad.

TIN RESEARCH DURING 1953

A series of new bearing metals, now undergoing practical trials, contains 30, 20, or 15 per cent of tin alloyed with aluminium; the two latter may be bonded respectively to strong aluminium alloy and steel backing shells. The 15 per cent alloy is being prepared for trials by some of the largest manufacturers of automobiles.

A new white alloy of copper, manganese and tin which takes a high polish and is suitable for rolling and stamping, may find applications in tableware and in the electrical industry.

The Institute's tinplate researches have again been principally concerned with the study of the tin-iron alloy layer, since the solderability and the corrosion resistance of tinplate are closely linked with the amount of the alloy and its structure.

Chemical compounds of tin, in which the tin atom is directly joined to the carbon atoms of organic radicals, are being systematically studied. In the last few years, some of these compounds have been used as a stabilising ingredient in certain plastics, and the current consumption of tin for this purpose is some hundreds of tons, yearly.

The Report is available free of charge from: Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex, England.

SALTER BALANCES CALIBRATED IN NEWTONS

To meet the needs of universities, technical colleges and professional institutions, particularly those concerned with electrical science, spring balances calibrated in "Newtons" are now being supplied by Geo. Salter & Co., Ltd., of West Bromwich.

The Newton is a unit which was adopted by the International Electrical Technical Commission in 1950 and which has since been recommended by the Institution of Electrical Engineers for use in universities and technical colleges. The difference between the pound (or kilogramme) and the Newton is that the former is a unit of mass, whereas the latter is a unit of force, including acceleration due to gravity.

One Newton equals 0·2247 lb.; 1 lb. is the equivalent of 4·4503 Newtons, and a kilogramme equals 9·81 Newtons.

The Newton is being used in the instruction of students in a number of universities and technical colleges, but its general adoption has been hampered by difficulty in obtaining appropriately calibrated balances. Salter co-operation has now overcome this particular snag, and it is anticipated that the new unit will eventually displace the multiplicity of systems at present employed.

At the moment, Salters are able to supply two Newton-calibrated balances. These are:

No. 235. 0-20 Newtons × 1/10 lb., 6″ dial (200 divisions); actual load 20 × ·22473 = 4·495 lb.

No. 235. 0-50 Newtons × ¼ lb., 6″ dial (200 divisions).

LAYTON MACHINE-TOOL SHOWROOMS

Messrs. M. C. Layton Limited, the machine-tool distributors, opened their new showrooms on July 13th. These new showrooms provide a comprehensive display, on exhibition lines, of most types of contemporary machine tools.

The Company has been fortunate in securing spacious modern factory premises at Alperton, near Wembley, Middlesex. In addition to offices and reception rooms, an uninterrupted area of nearly 9000 sq ft is available as a showroom. Facilities are provided by which every machine on view can be demonstrated, and expert demonstrators are in attendance. It is the nearest thing to a permanent machine-tool exhibition in Great Britain, and demonstrations of special machines will be a regular feature. It is the hope of the Directors that "looking in at Layton's" will, in future, become a habit for everyone interested in machine tools.

The new showrooms are situated at Abbey Wharf, Mount Pleasant, Alperton, and can be reached in about thirty minutes by car from Central London.

DERITEND PRECISION CASTINGS LIMITED

The Technical Press was recently afforded an opportunity of visiting the factory of Deritend Precision Castings Limited, of Droitwich, Worcs., and seeing the wide range of castings they manufacture.

The Company makes extensive use of the "Lost Wax" process, often referred to as "Investment Casting," for the production of small, extremely accurate castings. The basic principle of this process is that, for every casting produced, an expendable wax pattern is required. Several of these wax patterns are mounted on a wax feed bar, to form an assembly, which is then "invested" to form the mould. The wax patterns are now eliminated by melting and burning out, leaving cavities into which the metal can be poured. After casting, the mould is cooled and broken open, leaving an assembly of castings which, after being cut away from the risers, have only to be cleaned.

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The **Houghto-Clean 439** and **440** Combination readily removes such residues as heavy drawing oils and pigmented compounds, all types of cutting oils, rust preventives and polar type smuts and soils from metals of all types. This is very simply accomplished by using normal Power Washing Machines without heat.

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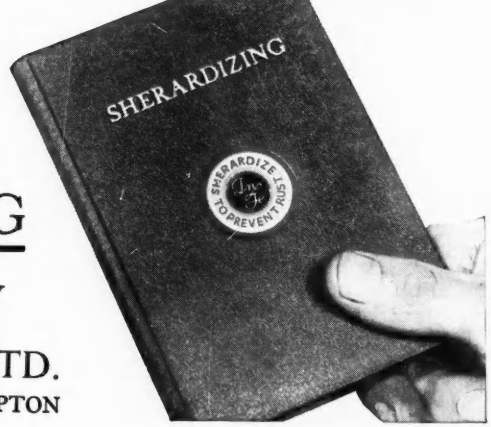

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LATEST INDUSTRIAL LITERATURE

1. Standard Jig Parts. Details of a comprehensive range of standard jig parts are contained in a well presented, illustrated catalogue. Parts include knurled-head location pins, knurled thumb nuts and thumb screws, swing eye-bolts, clamping screws and pads, slotted and plain clamps, washers, studs, feet pads and bolts, swing latches, and shoulder screws.

2. High-Frequency Inductor Motor Alternators. Descriptions are given in a 4-page leaflet of a range of high-frequency inductor-type motor alternators, designed for maximum service with a minimum of maintenance. These units are of robust construction and are dynamically balanced. They are of unit-case construction, and the driving armature or rotor and the alternator rotor are mounted on a single shaft with ball or rotor bearings. The shaft is of more than ample dimensions for the load it has to carry, and the bearings are very liberally rated.

Details are also given of a single-armature rotary converter, for very small machines with an output not exceeding 300 W, and where the supply is direct current.

3. Hack-Saw Blades. A neat 32-page booklet, entitled "How to Use Hack-Saw Blades," provides considerable useful information on the selection and use of hack-saw blades. The booklet includes details of tooth sizes, hand blades, light power blades, and heavy power blades, together with summaries of problems and their causes in connection with the use of such blades, including breakage, ripping out of teeth, and excessively rapid dulling.

4. Production Lathe. Details of a versatile production lathe with many interesting features are given in a well produced and illustrated 12-page brochure. Considering its range and work capacity, overall dimensions and floor space occupied are remarkably small.

Basically, the machine is a vertical-spindle chucking lathe, which incorporates twin slides and hydraulic feed. The slides and hydraulic cylinders form units which can be swivelled from below the horizontal to beyond the vertical position. This feature enables the lathe, apart from normal turning, to machine simultaneously two internal tapers, two external tapers, or an internal and external taper. Furthermore, although the machine is primarily intended for repetition work, it is so easily set up that it can be conveniently used for small quantities.

5. Wire-Rope Splicing System. Specifications and data are furnished in a series of pamphlets and brochures contained in a neat folder, of a patented and well proved wire-rope splicing system, the cost of which is considerably less than that of the conventionl hand splice.

Essentially, this splice is derived from a special clamp, which is a non-corrosive alloy ferrule with very high strength and cold-forming characteristics. When the ferrule is squeezed around the wire rope under high pressure by a special hydraulic press, the metal "flows" into the space between the wires in the strands and the strands themselves, producing a splice which is as strong as the rope itself. In addition to their high strength and economy, these splices are non-corrosive, watertight, permanent, and of neat appearance. Furthermore, as the thimbles are wedged tightly in the loop, they cannot slip or fall out.

6. Springs. Progress in industry has introduced many new problems relating to springs and their applications. A new 40-page handbook, published by a firm which has for many years produced high-quality springs and spring pressings to a high degree of accuracy, does not, however, touch on complex spring problems, but serves as a handy reference for spring designers, buyers, and users.

The contents include chapters on the design and ordering of helical extension and compression springs, wire forms, helical torsion springs, flat springs and pressings, and spring tolerances. Useful reference and conversion tables are included.

7. Cutter-Grinding Equipment. Details are given in an illustrated 8-page brochure of a cutter grinder which enables cutters to be maintained in perfect cutting condition, with a factory finish to their edges, whenever they require renewal. Complete control and unhampered vision while the machine is in operation permit set-up and resharpening to be effected in from 15 to 20 minutes, according to the type of cutter.

The machine, which requires only 24 in. × 30 in. of floor space, is of robust, yet compact, construction, is easy to set up and operate, and is ideal for sharpening counterbores, countersinks, reamers, slot drills, end mills, face mills, Woodruff cutters, tee-slot cutters, spot-facing cutters, side and face cutters, cylindrical cutters, angle cutters, and hollow mills.

8. Machinery Installation. A method of machinery installation, based on the use of felt and glue, is described in an illustrated pamphlet. With this method, no damage can be done to floors, as the felt pads keep machine bases off the surface, and no bolting or grouting is necessary. Installation is naturally exceptionally easy, inasmuch as the machine is, so to speak, virtually "stuck" into place, and, once installed, stays in position until it is required to be moved—a simple and rapid operation.

9. Rubber Springing System. Details of a torsional rubber springing system, basically intended for the wheel suspension of vehicles, are contained in two well produced and illustrated pamphlets. In essence, the system comprises a centre shaft and an outer trough-like shell, between which rubber is bonded. The shape of the shell permits locked-up stresses to be relieved during manufacture, while a bolted-on top plate provides radial pre-compression to the rubber, thereby improving fatigue life.

Advantages of the system include the fact that an oil-less bearing is provided by the rubber, and that insulation is provided against high-frequency shocks, vibration, and noise. Furthermore, the system requires no maintenance, is simple in design and convenient to instal, and resists corrosion and dirt.

10. Single-Shaft Gas-Turbine Engine. Beautifully produced in colour, an 8-page booklet gives details and specifications of a single-shaft gas-turbine engine with a continuous-power rating of 60 bhp. Its lightness, reliability, ease of starting, freedom from complicated electrical systems, and its immediate full-power availability under widely varying climatic conditions make it an ideal prime mover for pumping and generator sets, air compressors, and similar units. Engine operation is extremely simple, full control during running being obtained from a single lever.

The engine is supplied as a lightweight, self-contained, portable unit, mounted on a tubular frame, complete with fuel tank, control lever, and fully equipped instrument panel. The weight of the complete assembly is only 168 lb, the bare engine weighing 116 lb.

11. Metal-Sawing Machinery. A range of metal-sawing machinery is described and illustrated in a well produced 16-page brochure. These machines feature a special, balanced feed circuit, which has been designed to suit metal-sawing conditions and which has several advantages, among which may be mentioned the following:—Any tendency of the saw blade to be drawn into the work by its own cutting action is prevented; equal tooth loading is obtained, irrespective of the number of teeth engaged; temperature changes have practically no effect on feed rate; and steady and positive approach of the saw blade to the material, and an equally steady break-through at the end of the cut, are obtained.

The brochure also includes details of a series of saw-sharpening machines, and instructions for the use and maintenance of segmental saws.

12. Friction Clutches. Details of a comprehensive range of friction clutches for a wide range of applications are contained in a neatly produced and lavishly illustrated 12-page catalogue. These units are dustproof, will not fire or spark, are perfectly balanced, easily adjusted, and suitable for any class of drive. Furthermore, the friction discs wear evenly and retain their shape; load pick-up is gradual and there is no starting shock, the small sliding sleeve movement permits fixing in confined spaces, and they will run in either direction, without alteration in design.

A supplementary catalogue describes a range of multi-stage centrifugal blowers and exhausters for all applications requiring air at pressures up to 7½ psi or vacua up to 10 in. of mercury.

13. Hand-Operated Lifting Truck. Specifications are given in a 4-page brochure of a compact lifting truck of welded tubular construction, combining strength with lightness, and designed for ease of handling and manoeuvrability. The platform, 20 in. in width × 16 in. in depth, is mounted on four grooved rollers and runs freely on the front tubes, while a high-capacity, specially designed pump is mounted integrally with the ram, and is fitted with a conveniently located pump handle, proportioned to minimum effort. The unladen weight is 90 lb, the maximum load is 280 lb, and the maximum lift is 3 ft.

Apart from the standard model, a convertible model is also available, and is designed for the easy adaptation of such special-purpose attachments as pallet forks and barrel- and drum-lifting devices.

14. Shutter Gates. In a well produced folder, information is given of a range of shutter gates designed for strength and ease of operation. These gates embody in their construction a collapsible gate, to which are fixed manganese-bronze hinging strips running the full height of the gate. These hinging strips carry the shutter plates, which are made from 16 s.w.g. material.

The shutter gates are top-hung on bearing rollers running in a box-type top track. the type of the bottom track being dependent on site conditions. The gates can be finished to suit any scheme of decoration, and lend themselves readily to any architectural design, without, however, sacrificing ease of operation.

15. Aluminium Paste. The outstanding advantages of aluminium paste over aluminium powder in the manufacture of aluminium paint are the removal of the dust nuisance, the very considerable reduction in bulk volume, and the smoother paint film obtained. A well-produced and illustrated 32-page handbook gives comprehensive information on the subject of aluminium paste, including its manufacture, properties, and special advantages.

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BOOKS RECEIVED

Strength and Elasticity of Materials. Vol. III. By W. H. Brooks, Ph.D.(Eng.), B.Sc.(Eng.)London. 317 pp., 193 illustrations. Publishers: Macdonald & Co. (Publishers) Ltd., 16 Maddox Street, London, W.1. Price: 25/-.

This volume supplies solutions to all Part II Examination questions set in the Internal papers of the University of London, from 1940 to 1950 inclusive, and therefore supplements Volumes I and II, which contains solutions to Part I questions. As in these previous books, solutions have been grouped in appropriate sections, each dealing with questions of a particular type.

Prospective candidates will find it advantageous to work through the questions set in one or two complete papers, prior to presenting themselves for examination—choosing a minimum of six questions, and finally checking their answers by those given in this book.

Although these are London University questions, students taking their Part B A.M.I.Mech.E. examination in Materials or the corresponding part of the A.M.I.C.E. paper in Materials, will also benefit by working through this book.

Vector and Tensor Analysis. By G. E. Hay, Ph.D. 224 pp., 65 illustrations. Publishers: Dover Publications, Inc., New York. Price: cloth, $2.75; paper, $1.50.

This handy little volume, which is primarily intended for students of engineering and mathematical physics, provides sufficient treatment of tensors and tensor methods to permit their use in classical mathematical physics.

Chapters include elementary operations, applications to geometry, application of vectors to mechanics, partial differentation, integration, and tensor analysis. In each chapter, representative problems are given; altogether, the book contains 195 such problems.

Detailed explanations of all points covered are given, and the applications of theory are kept separate from its explanation.

Practical Sheet and Plate Metal Work. 6th Edition, 1954. By the late Arthur Atkins, M.Sc., M.I.Mech.E., M.I.W.; revised by W. A. Atkins, L.I.M., N.Inst.Met., M.I. & S.I. 508 pp., 372 illustrations. Publishers: Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price: 20/-.

In this new edition, the text of this well known book has been completely revised and brought into line with most modern practice. The subject has been approached from a practical viewpoint, and a valuable feature of the book is the attention given to the setting out of patterns for all types of work.

Several examination papers of the City and Guilds of London Institute and the Union of Lancashire and Cheshire Institutes appear at the end, so that it is not only of value as a reference book for those who are actually engaged in sheet-metal work, but also useful to those who are desirous of taking certificates in the subject.

The Master Engineers. By Emmeline Garnett. 223 pp., 26 illustrations. Publishers: Hodder and Stoughton Limited, London, E.C.4. Price: 12/6.

In "The Railway Builders," Emmeline Garnett gave us an insight into the life and works of George Stephenson and his son Robert. This companion volume is a biography of another famous father and son—the Brunels.

Marc Isambard Brunel escaped from France during the Reign of Terror and, after a successful career in America, finally settled in England, where he first received favourable attention by his new system of machinery for making blocks for ships' rigging. His greatest achievement, however, was the Thames Tunnel, for which he invented a piece of tunnelling machinery, known as the Shield, which, for sheer ingenuity, was probably one of the contemporary wonders of the world.

His son, Isambard Kingdom Brunel, was an equally distinguished engineer but, more than that, he was a visionary. Railways, bridges, steamships, he took them all in his stride. The Great Western Railway was his, so too were the Box Tunnel, the longest in the kingdom, and the Wharncliffe Viaduct at Hanwell. He suggested the then fantastic idea of a transatlantic steamer, and brought the idea to fruition in *The Great Western*, culminating in that glorious and tragic failure, *The Great Eastern*, the monster luxury ship.

The achievements of this man, who has been described as "the Michael Angelo of modern engineering" are well summed up in a newspaper obituary:—" . . . Success and failure were his right hand and his left—success in the line of inventive art, failure in the results of reproductive art. Unlike Stephenson, who made everything pay, Brunel made nothing pay. As an engineer, he raised the mightiest works, and ruined the richest men . . ."

The book is written in a documentary style and is enlivened by extracts from diaries, which, together with excellent illustrations by Wardill, afford a fascinating glimpse of life and customs in the nineteenth century. In short, a delightful book, affording relaxation to Engineers, instruction to laymen, and absorbing interest to both.

Meter Engineering. 6th Edition, 1954. By J. L. Ferns, B.Sc. (Hons.), M.I.E.E., A.M.C.T., A.M.I.I.A. 363 pp., 199 illustrations. Publishers: Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price: 27/-.

Ever since its first publication in 1932, this informative and authoritative text-book on the testing and maintenance of electricity meters has enjoyed a deserved popularity. In this new edition, although no fundamental alterations have been made, the opportunity has been taken to bring certain abbreviations into line with modern practice, and to refer to changes in meter practice.

The theoretical portions of the book assume a certain amount of mathematical knowledge on the part of the reader, such as elementary integration, vector summation, and certain trigonometrical identities. Appendices are added, however, for those who have not yet attained a corresponding stage in their studies.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

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The inclusive fee for the course of study is £71 1s. 0d. In certain cases where a student is not sponsored by an employer, the University may consider applications for the remission of this fee and, where essential, for the grant of a maintenance allowance during the period of attendance.

Further particulars and application forms may be obtained from the Registrar, The University, Edgbaston, Birmingham, 15.

APPOINTMENTS VACANT

ELECTRONIC ENGINEER. Applications are invited from men preferably between 28 and 35 years of age, for an appointment with a large firm in connection with applied nuclear energy engineering research and development. Applicants must have an honours degree in electrical engineering with experience in light electrical engineering and/or electronics with about six years' experience in industry, and be familiar with or have a working knowledge of electric control gear and instrumentation. A knowledge of servo mechanisms and their application would be an advantage but is not essential. Salary would be comparable with that paid by the Civil Service, London rate, the grading depending on age and experience. Apply in the first instance to Box No. 123.

ARMSTRONG SIDDELEY MOTORS LIMITED, have vacancies for Technical Assistants for research and experimental work on aircraft gas turbines; particularly on compressors, turbines and aerodynamic flow problems. Engineering Degree, HNC or equivalent necessary. Write in detail to Reference GWB, Personnel Manager, **Armstrong Siddeley Motors Ltd.,** Coventry.

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *CATHODIC VACUUM ETCHING*

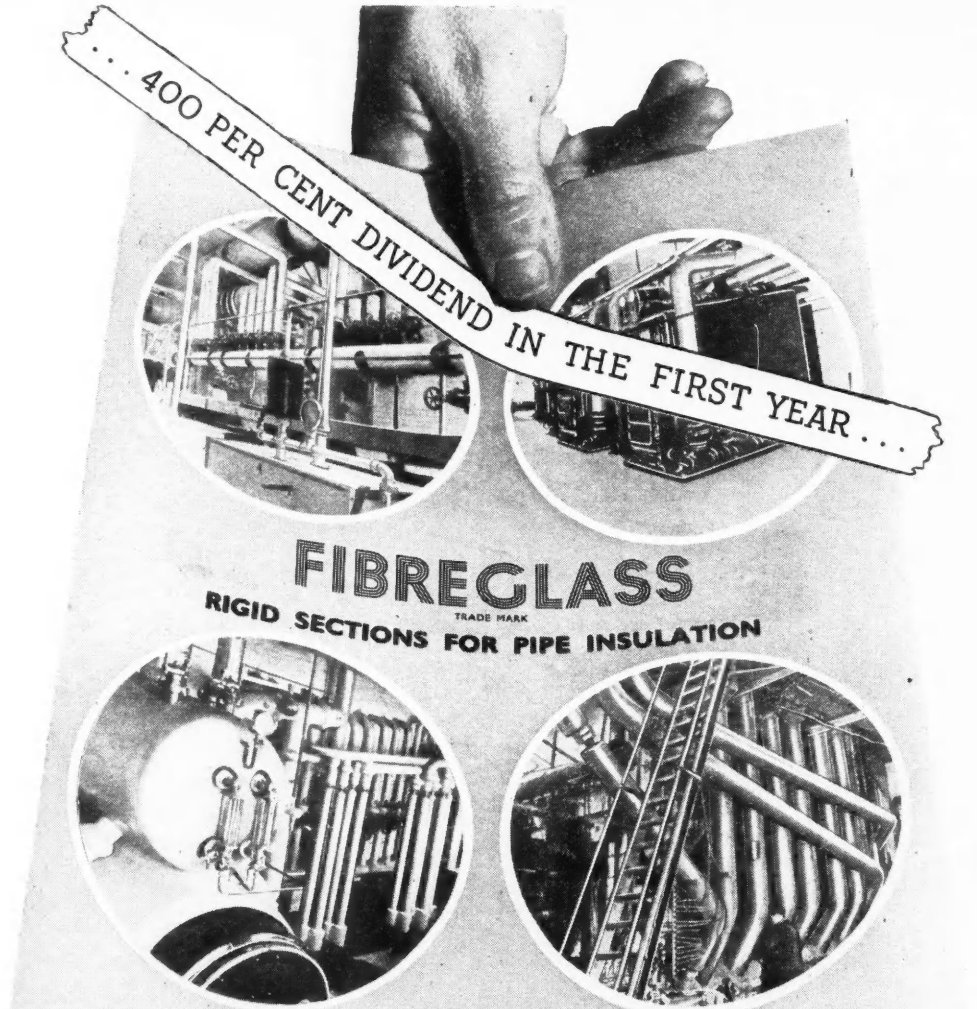
In the so-called " sputtering " process of metal film deposition by vacuum glow discharge, the cathode is subjected to positive ion bombardment, so that metal is ejected from its surface. The removal of metal from the cathode surface is not completely random, but is related to the microstructure of the cathode. In consequence, the resulting etched surface is similar in appearance to surfaces produced by chemical or electrochemical etching. This specific application of sputtering to the development of the macrostructure and microstructure of metallographic specimens has been termed " cathodic vacuum etching." By introducing certain improvements in the process, etching times have now been reduced to from one to three minutes, as compared with from the one to three hours previously required. In the new equipment the cathode is so designed that high current densities can be used without heating the sample excessively. This also makes it possible to standardise etching conditions, although the samples are of various sizes and shapes. The effective area of the cathode is fixed; therefore, the electrical conditions for etching can be standardised. The fittings are made of zirconium and aluminium because of the slow etching rates of these metals. A particularly important advantage of the vacuum etching process is that, unlike chemical etchants, cathodic vacuum etching appears to be non-specific in nature, so that the microstructures of the various components of complex materials are developed simultaneously and the interface areas are well preserved. Cathode vacuum etching has other possibilities, such as removing oxides from intricately shaped metal pieces and preparing standard surfaces for corrosion studies. Etching of non-conductors, such as ceramics, for microstudy is another possible application of the method.

● *NICKEL PLATE WITH SPECIAL PROPERTIES*

It is reported that patents have been applied for a novel nickel sulphamate plating bath which produces nickel coatings with special properties. Applications are said to lie mainly in such operations as re-sizing worn or incorrectly machined parts, the production of heavy coatings for various purposes, and electro-forming. The hardness of the coating produced is claimed to approximate 600 Vickers. In spite of this high hardness, internal stresses are low and abnormal brittleness is absent. The basic constituents of the bath are nickel sulphamate, nickel chloride, and boric acid. A modified bath also contains naphthalene 1, 3, 6-trisulphonic acid as additive. It is this additive which has a marked effect upon the properties of the nickel deposit by increasing its hardness, creating an internal compressive stress, and increasing tensile strength and electrical resistivity. Where particularly high electrical resistance is required, cobalt and organic agents may be added to the bath, producing an almost two-fold increase in resistivity. In salvage operations on tools, crankshafts, diesel cylinder liners, etc., nickel is plated to thicknesses as high as from 0·03 to 0·05 in. The hard nickel plate may be used for the entire building up or for a large portion of building up followed by chromium. Electro-forming which involves plating on matrices or patterns is an important application. It is considered that the stress characteristics of the deposit and its hardness and wear resistance constitute favourable factors. It is reported that the sulphamate process is used for reproducing geometric surface roughness standards by electroforming. Other applications include leather embossing dies and the electro-forming of wave-guides.

● *ELECTRONIC SHAKING DEVICE FOR TEST PURPOSES*

There exist many cases in which the generation of precise mechanical motions is required for test purposes. Typical examples are the testing of thermionic tubes, exciting of vibrational modes in propellers or turbine blades, testing air frames, and the dynamic calibration of seismometers, accelerometers, and pick-ups. The testing of these instruments and devices by sinusoidal motions presents no particular difficulty. However, in studying the response of accelerometers and seismometers, it is desirable also to have the possibility of applying arbitrary transient or discontinuous motions of such wave shapes as steps, ramps, and repetitive square and triangular waves. For this purpose a transducer system has been devised which reproduces discontinuous motions with acceptable fidelity. In this apparatus the main electro-mechanical transducer executes the desired vertical motions. When an accelerometer is to be tested, it is clamped to its moving platform;



400 per cent dividend in the first year : as Fibreglass Rigid Sections are **AVAILABLE FROM STOCK** you can start reaping such benefits at once. Write for our booklet now. An uninsulated 3-inch main, 100 feet long, carrying steam at 400°F wastes fuel at the rate of 13.8 pounds every hour—54 tons in a year of 8,000 working hours. Insulated with Fibreglass Rigid Sections, 2-inches thick (with fixing the cost is about £50) the loss is reduced to 4 tons of coal a year — a clear saving of 50 tons — a sheer gain of £200. Fibreglass insulation is paying 400 per cent dividend in the first year.

FIBREGLASS LIMITED, RAVENHEAD, ST. HELENS, LANCS. TELEPHONE · ST HELENS 4224

a power amplifier serves to energise the force coil with varying currents in the image of the desired waveforms, and the force coil in turn actuates the main transducer platform. A low-frequency electronic oscillator supplies cissoidal oscillations, while a simple type of wave shaper provides square and triangular waves from the oscillator output. An arbitrary wave generator of the photoelectric type utilises a mask, cut to the desired mathematical function. This mask intercepts a light beam focused on a phototube to produce electromotive forces of the desired wave form. These are used to drive the power amplifier. Three feedback circuits are incorporated, one producing a voltage proportional to the moving platform displacement, the second to its velocity, and the third to its acceleration. A dual-beam cathode-ray oscilloscope provides a display of the platform motions and the electrical output of the accelerometer or other device on test.

● *NEW PLASTIC FOR WIRE INSULATION*

A valuable new plastic material for the insulation of wires and cables is produced by the treatment of polyethylene with chlorine and sulphur dioxide. In this process the chlorine is substituted along the hydrocarbon chain and the sulphur is combined with chlorine and attached to the chain as sulphonyl-chloride groups. As the new material constitutes an elastomer, it requires the incorporation of vulcanising agents and activators for curing. It can be vulcanised with a combination of metal oxides, accelerators, and organic acids. The curing process involves the cross-linking produced by the reaction of the sulphonyl-chloride groups with metal oxides in the presence of an organic acid and an accelerator. Compounds of the material can be processed in standard rubber machinery. For extrusion, conventional rubber extruders may be used; in addition, extruding onto wire and curing can be carried out on conventional machines. It is considered that the new material should prove of interest in many applications as a possible replacement for wire coverings for both insulation and outer cover. The material has adequate electrical properties to serve as an insulation for many applications and, at the same time, possesses the combination of toughness, chemical resistance, and weather resistance required in an outer cover. Its heat resistance appears particularly noteworthy, making the material eminently suitable for wire insulation. In a composition specifically compounded for heat resistance, the new plastic has been found suitable for intermittent use at 300° F. Resistance to ozone cracking is a desirable property in any material used in wire and cable manufacture, and in this respect the new elastomer is said to have such outstanding qualities that it is now being used in the form of gaskets for ozone generators.

● *HIGH-SPEED CAMERA*

A new high-speed camera has been devised which is capable of attaining speeds of fifteen million frames per second and which will take 96 consecutive exposures of a single event. This camera is considered especially useful for recording explosive phenomena and similar high-speed actions. There is no doubt that its perfection constitutes a remarkable advance over an earlier type which was capable of 3,500,000 frames per second. The new camera embodies a three-sided mirror which rotates at 23,000 revolutions per second and sweeps a beam of light across a row of lenses to form a series of pictures. The mirror is made of a special steel which has a tensile strength of over 300,000 psi and which spins in a helium atmosphere on oil-pressure-lubricated bearings and is powered by a small helium-driven turbine. Since the entire strip of film is exposed in about 1/150,000 sec, no mechanical shutter could be devised to close rapidly enough to prevent the reflected beam from sweeping across the film a second time and thus exposing the film twice. An electrical detonator was therefore arranged to shatter a glass block in the path of light, the shattered block being sufficiently opaque to keep out light until a mechanical shutter comes into action. The film used is standard high-speed 35-mm film and is not hypersensitised.

● *ANTI-CORROSION COATINGS FOR MAGNESIUM*

A recently released report gives interesting information on efforts made to develop anti-corrosion coatings for magnesium. The report describes formulation and evaluation of three series of experimental primers and the further development of organic coatings to impede the corrosion of magnesium alloys. The constituents used in the first series of tests consisted of magnesium chromate, magnesium chloride, magnesium sulphate, and other magnesium compounds. Graded amounts of these various magnesium salts were used to replace an equivalent volume of zinc chromate in primers based on a phenolic resin vehicle. In the second series such constituents as zinc chromate, zinc oxide, micalith-G, and aluminium stearate were tried out. The third series consisted of such constituents as zinc chromate, zinc chromate selenate, strontium chromate, calcium chromate, barium chromate, etc., based on a phenolic vehicle in which the inhibitive pigment constituted 80% of the total pigment volume of each primer. The panels used in the experiments were untreated magnesium alloy sheets which had been properly cleaned and degreased. After application of the various protective coatings, the panels were tested by marine exposure at various localities; salt-spray tests in the laboratory were also carried out. It was found that the substitution of magnesium chro-

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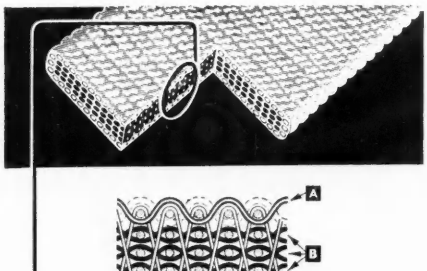

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mate and magnesium fluoride for part of the zinc chromate in phenolic primer tends to improve protection against corrosion offered by the primer. For the inhibition of magnesium-alloy corrosion by paint films, barium chromate proved to be an unsuitable source of chromate, while zinc chromate and calcium chromate appear to be the best inhibitive films tested.

● *EXTRUSION OF STEEL INGOTS AND BILLETS*

In the extrusion of steels, especially stainless and alloy steels, a heated billet or ingot is inserted into a cylindrical extrusion chamber with an extrusion orifice or die at one end and the metal is then expelled in the form of a bar or a tube. It is essential to ensure that the metal should not be subjected to an excessive temperature drop as it issues through the die, since otherwise the die orifice would soon be obstructed by a plug of solid metal. At the same time, it is necessary to prevent excessive heating of the die and to provide a lubricant. These requirements are met by the use of molten glass as lubricant, a glass disc being placed between the front end of the billet and the die, so that in the extrusion process the metal is covered by a layer of molten glass. It is well known that this process is meeting with a large measure of success. A recent invention aims at a further improvement of the extrusion process by using, instead of glass, a solid infusible heat-insulating and lubricating composition in the form of a cake. In order to preclude any heat loss from the metal to the die, the composition of the cake includes an exothermic material which releases heat during the extrusion process. A composition which is claimed to have proved especially suitable contains by weight 10% sawdust, 60% flaked graphite, 23% carbon black, 3% manganese dioxide, and 4% linseed oil, in which the manganese dioxide reacts exothermally with the carbon. Other metal oxides, such as lead oxide or bismuth tetroxide, are also suitable as reagents.

● *PRODUCTION OF SPLINES BY COLD WORKING*

A new process for the production of splines, oil grooves, serrations, and other similar shapes on external parts has been developed and is now being introduced into practice. In the special machines built for this purpose, the rolling of splines is accomplished by a cold-working process in which the metal shaft is placed between forming racks. Two slides, carried in an extremely heavy machine frame, hold the forming racks, the slides being mounted one above the other. The slides are geared together with master racks (not the tool racks) and a connecting gear. The lower rack is powered by hydraulic cylinders. The working distance between the tool racks can be adjusted to obtain proper size of the finished product, and the tool racks are also adjustable lengthwise to obtain correct relationship with the axis of the workpiece. A small serration is used at the start of the rack to effect initial rotation of the workpiece which is supported by a centre and a yoke. Racks up to 50 in. in length are in use. Since all stresses occurring in operation are compression stresses and not shear stresses, it is reasonable to assume that the long tool life claimed for this type of machine will be realised in practice. The racks are made of high-carbon high-chromium steel, and the teeth are ground on a special machine designed to produce very high accuracy in spacing, pressure angle, helix, etc. Both the forming racks and the workpiece are cooled by an automatic coolant system. It is reported that parts provided with splines by this method have been found to withstand high torsion loads, and it is expected that the increased load capacity obtained will make it possible for designers to take advantage of finer splines.

● *ELECTROSTATIC CONTROL OF JET DIRECTION*

A recent invention envisages the electrostatic control of the direction of gas jets produced by jet engines, and it is claimed that in this way at least part of the jet can be utilised for steering or braking purposes. This proposal is based upon the observation that the jets of jet power units are generated by thermal and chemical combustion reactions which result in a partial dissociation of the reaction products into ionised particles. Such a dissociation is, of course, a function of the temperature of the gases and is therefore present to a considerable degree in the gases escaping from rockets and rocket motors. Similar conditions would prevail if nuclear energy should be resorted to for powering rocket motors, as the products of nuclear reactions also contain ionised particles. According to the proposals of the inventors, the direction of such an ionised gas stream is to be controlled by submitting it to the influence of an electric or magnetic field, which would be so arranged as to exert a deflecting force upon the ionised particles. In cases where the degree of ionisation of the gas stream is too weak to be effectively acted upon—as, for instance, in the case of conventional types of jet engine—additional artificial ionisation is proposed. This is to be accomplished by providing an ionisation device upstream of the deflecting field. In this case, the requisite electrode is to be made with a shape which produces a stationary aerodynamic shock wave, so that the aerodynamic shock will add to the electrostatic ionisation. Apart from the obvious difficulty of providing suitable electrical equipment, investigations would first have to be made as to whether sufficient mechanical effect can be obtained by such means. A study of the theoretical aspects of the proposal may therefore prove of interest.

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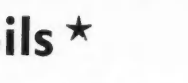

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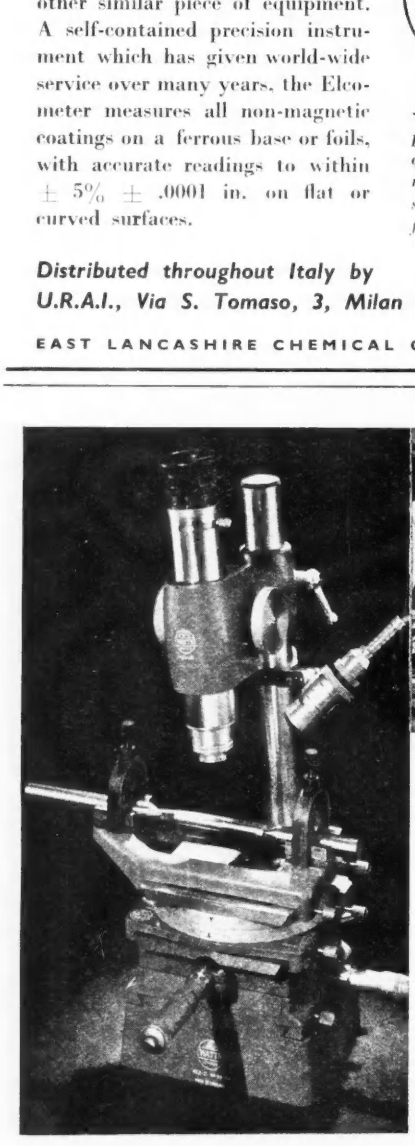

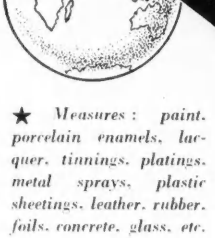

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● *METAL-POWDER COMPACTS FOR DEEP DRAWING*

When considering the production of cartridge cases by powder-metallurgical methods, it was found impossible to produce the thin wall section of the case directly from powder by standard methods. It is, however, possible to produce satisfactory preforms, which can then be deep-drawn. When developing the process, the drawing of these cups presented a problem chiefly in the first steps, as the material in the side walls compacts to practically 100% density within the first or second draws; in succeeding draws the material then behaves very much like wrought material. There is, however, an important difference between the sintered iron and the conventional cup, insofar as the material distribution in a sintered iron can be varied to any desired degree by design of the preform. These preforms are produced by standard powder-metallurgical methods without any machining, using hydrogen-reduced iron powder. The addition of a small percentage of carbonyl iron powder was found helpful, but is not absolutely necessary. After moulding on a mechanical press to a density of from 78 to 80%, the pieces are sintered in hydrogen or cracked ammonia at from 2100 to 2300° F, and then coined in an hydraulic press. This is followed by a final anneal to 2300° F, which appears to have a beneficial effect on the ductility of the material. It is possible that the increased ductility is due to a change in pore shape, since a rounding of the pores seems to occur. For deep drawing, the cups are copper-plated, the copper acting as a lubricant between the piece and the drawing punches and the dies. In some cases, a heavy soap solution, in addition to the copper plating, may prove helpful.

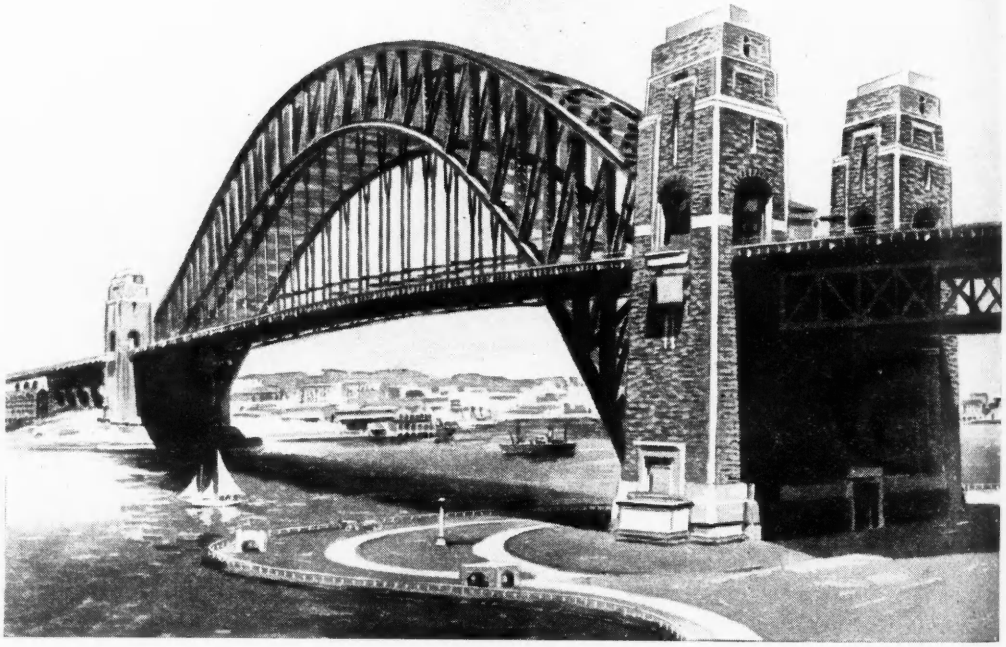
● *NEW HIGH-STRENGTH TITANIUM ALLOY*

Persistent efforts to improve the mechanical properties of titanium have resulted in the development of a new complex titanium alloy of high strength and ductility, which is forgeable and can be heat-treated to desired strength levels. At an early stage of these investigations it was found that certain beta-phase stabilising elements offered greater promise than the interstitial alpha-phase stabilisers, i.e., carbon, oxygen, and nitrogen. The new alloy was evolved from a series of experimental alloys, in which four of the five alloying elements (manganese, chromium, iron, molybdenum, and vanadium) were held constant at 1%, while the fifth element was varied. In this way it was finally found that an alloy containing 3% manganese with 1% each of chromium, iron, molybdenum, and vanadium has a remarkable combination of strength and ductility. The tensile properties of this alloy can range from 135,000 psi and 31% elongation in one inch, to 220,000 psi and 4% elongation, depending on the heat-treating cyle employed. It was also found that a transition structure, called the omega phase, is instrumental in hardening beta-stabilised titanium alloys. The omega phase is produced by solution treatment and subsequent ageing at less than 900° F. This phase, which hardens and embrittles the material, disappears after prolonged ageing and is replaced by a finely dispersed alpha-phase structure which possesses the required strength and ductility values. The new alloy is reported to exhibit machining characteristics resembling those of conventional stainless steel. For milling and sawing, best results are obtained by using slow cutting speeds, heavy feeds, and a lubricant with a carbon tetrachloride base.

● *SURFACE HARDENING BY CARBO-NITRIDING*

Several patents of recent date describe improved methods for the surface hardening of ordinary carbon steels, alloy steels, and cast iron by gaseous carbo-nitriding with carbon and nitrogen simultaneously. In one of these methods, carbo-nitriding is carried out at a temperature at which the core of the workpiece remains in the alpha state, stable in the cold, while, owing to carbo-nitriding, the surface layers become austenitic and are subsequently quenched by cooling at a suitable rate. It is claimed that in the latest method evolved, substantially higher rates of diffusion are achieved than in the aforementioned method, so that time of treatment is considerably reduced. This latest method consists in carbo-nitriding at a temperature between the Ae_1 and Ae_3 point of the material to be treated. This is followed by cooling to a temperature between the Ae_1 point of the core and the Ae_3 point of the carbo-nitrided layer. The material is then maintained at this temperature until the austenite of the core is entirely converted into ferrite and cementite, while the carbo-nitriding layer remains entirely austenitic. Finally, the material is rapidly cooled to transform the carbo-nitrided layer into martensite. The low carbo-nitriding temperature employed is said to produce a finely grained carbo-nitrided layer of a high degree of hardness and good resiliency. Owing to the low temperature, distortion of the workpiece is kept to a minimum. The depth of the carbo-nitrided layer amounts to from 0·2 mm to 0·3 mm after treating for three hours at 750° C, depending on the percentage of alloying constituents present. Surface hardness is between 800 and 1050 Vickers, and it is claimed that the martensite is of extreme fineness.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



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